Hunter-gatherer adaptation in the deserts of northern Patagonia

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This research focuses on land use and risk management by hunter-gatherers in the Diamante valley, northern Patagonia, Argentina, across three ecological zones: the Highlands, the Piedmont, and the Lowlands. I also explore how site structure differed within these ecological zones, how mobility was used to manage the heterogeneous distribution of resources, and how ceramics were used in the context of high residential mobility. To determine the differences in land use, the fieldwork for this research involved a systematic random sample of surface deposits from 400 one-hectare units within a 100 km^2 area in each ecological zone, followed by lithic and ceramic analysis of the materials recovered.

The Piedmont contains the highest density of human activity, followed by the Highlands, and then the Lowlands. In the Lowlands, the relative absence of evidence for human activity suggests this was an inhospitable place for people to live. In both the Piedmont and the Highlands, larger sites close to water courses and to raw materials were occupied repeatedly. Across the region, the most common raw material was basalt, followed by cryptocrystalline, and then obsidian. Chipped stone implements and fragments in the Highlands were smaller than in the other areas. In the Highlands, the most abundant camps were of medium size, possibly located and organized to support logistical foraging trips to acquire resources in a patchier environment. Ceramics were more abundant in the Highlands, but required only minimal investment suggesting they were used for only short periods of time. In addition to ceramics, obsidian was also more important in the Highlands than it was in the Piedmont. I examine how patterns of human mobility complement the use of resources across different ecological zones, nothing that the Piedmont, which is accessible all year round, was used the most. These findings contribute to our understanding of the diversity of evolutionary trajectories of small-scale groups in marginal environments by the use of a variety of adaptive strategies.

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Little moments. Just little moments. Do not waste any second in pettiness. Life remains the largest mystery of all. *De lo pequeño a lo grande, la distancia es tiempo*. Until the next glimpse all we have is each other. Through the journey we tend to think that these encounters with others do not follow any logic but respond to some unplanned whim. Of course! but what a beautiful whim! And yet, a web (fabric) of intertwined little moments turns up in our path. In the solitude of the last breath I hope a fiery spark ignites a last fresh smile in which I recall all the names—all of you who made this journey a blast.

To Loukas,
the master mind behind this work
the one who showed me "the line"

1.0 Small-scale societies adaptations to deserts and altitude

1.1 **Introduction**

This research focuses on adaptations of small-scale human groups to the environmental risk and uncertainty of marginal environments over long periods of time. In particular, I am interested in how prehistoric hunter-gatherers combined residential mobility, storage, trade, and technological innovation to manage variability in the spatial and temporal abundance of resources in arid northern Patagonia. The archaeology of the region (Figure 1) will generate insight for understanding how human groups adapt to nutritional and altitudinal stress in similar contexts in other parts of the world.

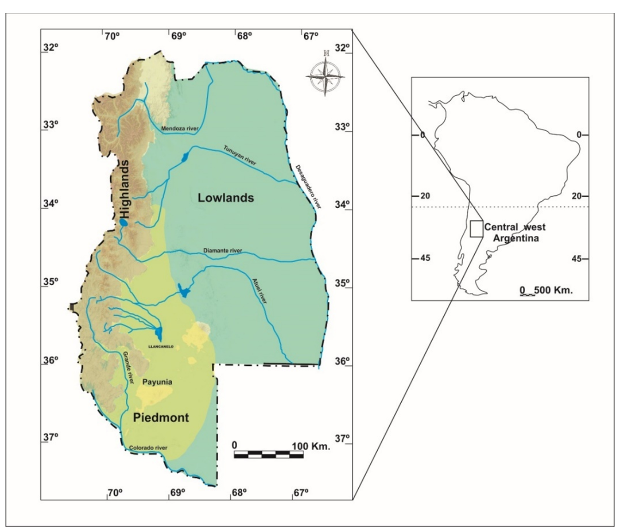

Figure 1.1 Map of Mendoza province, Central West Argentina, with main rivers and delimitations of ecological zones.

Archaeological research over the past 20 years suggests that, in spite of their proximity to farmers, Late Holocene people of Patagonia did not cultivate domestic crops but instead subsisted on wild camelids, large flightless birds, small game, and seeds (Gil 2006; Neme 2007). Around 2,000 years BP[1], demographic pressures, perhaps the result of human population growth, may have forced more intensive resource procurement and processing behaviors as well as more regular and extensive interaction between individuals and groups over large areas. On the other hand, current data reveal that human population declined between 700-600 years BP. This decline may have occurred in the context of the Little Ice Age, the Inca expansion, and the Araucanization process, when indigenous southern Mapuche groups expanded across Patagonia after adopting the horse (Gil et al. 2014). These processes remain as lines for future research, as very little is known about them today. The complexity of these demographic and ecological trends requires careful evaluation of social and environmental change during the Late Holocene (Neme 2009).

The study of evolutionary trajectories of adaptation in arid environments is best approached with a biogeographical perspective (Veth et al. 2000; Borrero 1989; Neme and Gil 2008a) focused on understanding variation in the use of space across different areas. This is especially relevant in southern Mendoza because resource productivity and distribution within and among spaces varies in response to the enormous variability in average annual rainfall, topography, elevation, and the distribution of different soils across different ecological zones. Resources are therefore heterogeneously distributed and seasonally available in volatile and patchy environments. Average

[1] Dates related to periods of the Holocene are mentioned as years Before Present (years BP). They are based on non-calibrated radiocarbon dates. If not reported, the dissertation uses all dates in uncalibrated years BP as years BP, for the most updated report on chronological results in southern Mendoza see (Gil et al. 2014).

annual rainfall in the deserts of southern Mendoza is 250 mm. Humans inhabit elevations from 700 m above sea level in the Lowlands to 3,600 m in the Highlands (Neme and Gil 2012). Water is abundant in the Highlands during the summer but scarce in the Lowlands. While plant diversity is more abundant in the Lowlands, large animals, and therefore biomass, are more abundant in the Piedmont, though they move seasonally to the Highlands in summer (Roig 1972). Human ecology enables us to make sense of the similarities and differences in human adaptation, and provides a foundation for generating testable hypotheses about the relationship between environmental change and cultural evolution (Bettinger 1991a; Binford 2001; Kelly 1995; Yellen 1977; Neme and Gil 2008a; Garvey 2008; Borrero 2002, 2012).

Anthropologists study how different human groups manage technology and resources to overcome limitations of nutritional, thermal, and altitudinal stress. Hunter-gatherer adaptation to arid conditions show different trajectories across the world: the Great Basin of the US, South Africa, Central Asia, Australia and the Andes. In addition, comparisons of human adaptations to altitude focus on Tibet, the Andes and the Ethiopian plateau (Beall 2013). The archaeology of the last 10,000 years BP in the Diamante River valley of northern Patagonia, Argentina, provides an opportunity to study how mobility and use of land allowed the effective occupation of space by small-scale groups in a context of both arid and high elevation conditions.

Adaptations among small groups of hunter-gatherers enabled humans to colonize all continents at different latitudes, occupying a wide variety of ecosystems. Worldwide, hunter-gatherer subsistence systems had been the most stable way of life throughout human history up until the last 10,000-6,000 years BP, when both agriculture and socio-political complexity began to evolve rapidly. Across the globe, latitudinal and environmental conditions contextualize different strategies that involve the movements of people, transport of critical resources, group size, marriage networks, trade, storage and technology (Binford 2001). The degree to which these strategies and characteristics of social organization are used allows us to investigate both the constraints within the ecology of a region and the cultural trajectories associated with it. Some of the questions guiding the research agenda are: When did humans occupy these marginal areas? Are all adaptations to deserts and high elevation environments alike? If not, how and to what degrees do they differ? What role does technology play in the history of human occupation of these areas?

The South American continent presents geographic characteristics that shape the distribution of ecosystems, presenting different opportunities and constraints for human foraging: 1) great river basins in the tropical lowlands (Orinoco, Amazon, and Parana); 2) the cordillera de Los Andes, with its North-South orientation impacting the East-West ecological zones across the continent; 3) a large arid-semiarid diagonal that crosses the continent from the equator to 54° latitude; 4) an oceanic influence in the southern cone ameliorating climatic conditions that tend to be more harsh in the Northern Hemisphere; and 5) unexpected phenomena like the El Niño-Southern Oscillation (ENSO) and volcanism (Scheinsohn 2003). Among these characteristics, the last four ecosystems are of major importance to understanding human adaptation to high elevation and arid conditions in the Diamante valley. Particularly, the effects of latitude shape ecosystem diversity across the Andes, governing the amount of precipitation, length of the day, mean annual temperature and the amount of solar radiation received (Aldenderfer 1998).

There is a general acceptance (Aldenderfer 1998, Neme 2007, Barton 2016) that above 2,500 masl, elevation provokes serious challenges for human adaptation. In high elevations, low atmospheric pressure limits the amount of oxygen available to humans. When the body or certain organs are deprived of sufficient oxygen, a pathological condition called hypoxia occurs.

Furthermore, cold conditions affect the amount of energy required by organisms to maintain body temperature. Different aspects of human life are limited by marginal environments: health status, work capacity, nutritional status, reproduction and growth (Aldenderfer 1998). The ecology of high elevation and arid environments is marked by, 1) environmental heterogeneity, 2) extremeness, 3) low predictability, 4) low primary productivity, and 5) high instability and fragility (Beall 2013).

In addition to water scarcity, desert resources are heterogeneously distributed both in time and space. Furthermore, conditions related to topography, latitude, effective temperature, quality of soils and average rainfall affects the abundance of resources. Therefore, arid environments set constraints for human adaptation related to thermal and nutritional stresses.

1.2 **Use of space in contexts of volatility and unpredictability**

Human Behavioral Ecology (HBE) follows the principle of optimization, considered an outcome of natural selection, which acts on the morphological, physiological, and behavioral variability in a population (Bettinger 1991a; Winterhalder and Smith 2000). Natural selection tends to favor those individuals that are better prepared leading to differential survival under different environmental constraints. Though different components of behavior, such as time related to subsistence, social activities and mobility among others, do not work in isolation, on average they tend towards optimality. However, what is optimal in certain contexts may change across the course of evolution and what is favored by natural selection may differ through time and space.

Optimality Theory, with a set of models working as a tool kit, allows us to compare and test hypotheses about the relationship between human behavior and the environment. HBE simplifies reality so that we can discuss variables such as utility, use time, and costs that trigger the best decisions about prey-choice, patch-choice, raw material exploitation, and shifts in technology. This approach permits comparisons in the adaptation to marginal environments that work at different scales: the variability within and among different ecological zones.

The core concept for understanding adaptation in the marginal environments of the Diamante valley is risk, which means the possibility of falling below the minimal requirements for subsistence and therefore survival. For every foraging decision there is an expected mean and a variance associated with it (Winterhalder et al. 1999). In simple terms, risk implies that an expected outcome or return in a subsistence strategy is tied to a certain activities or choices occur in contexts of greater variance, while less risky activities and choices occur in contexts of lower variance (Winterhalder et al. 1999). Humans can manage this variance by averaging through different strategies: mobility, trade and storage (Smith 1988, Goland 1991, Cashdan 1990).

Goland (1991) explains temporal predictability by two properties: constancy and contingency. Constant resources are available across the whole year. Contingent resources are those only available during specific seasons, and their availability is unpredictable from year to year (i.e. inter-annual variability). When resources are constant across all seasons and from year to year, investment in storage is unlikely to pay off. If resources present a high degree of contingency at a certain location (i.e. resources predictably available in the summer, and predictable from year-to-year), then investment in storage may be optimal, to assure a differed consumption between periods of scarcity and availability. In contrast, if resources are constant but get depleted rapidly, we would expect foragers to move more often. Goland (1991) explains that storage allows people to average temporal resource variability, while mobility and exchange enable them to average spatial variability. The degree of resource abundance and heterogeneity in an environment, will condition mobility and settlement patterns. Moreover, ethnographic studies (Kelly 1995) show that movements are more often motivated by the need to acquire diverse resources and not merely to cover a caloric minimum. In addition, mobility reduces inter-group tension, permits the maintenance of social alliances and the exchange of information about complementary environments, all of which are extremely useful during lean years.

1.3 **Intensification in a volatile environment**

Sturm et al. (2016) defines marginal environments as continental, terrestrial landscapes with strong seasonality and marked temperature, precipitation, and biomass variation from year to year. Marginal environments were and remain useful to map the trajectories that foragers undertook in the process of optimizing resource management (Braidwood 1960, Binford 1968, Cohen 1977, Flannery 1969). This process can involve both an increase in the human population and a reduction in the abundance of the most optimal prey (Morgan 2015). To alleviate resource scarcity, hunter gatherers added different small animals or plants to their diet. In addition, the resource-dense places are occupied firstly, pushing other populations to less habitable environments. Because humans have to broaden their diets and occupy new territories, some archaeologists have described this as declining efficiency, whether achieved by the incorporation of more labor for the same resources, eating new species, or the occupation of new locations. This is called intensification, a process that occurs when there is an imbalance of population and resources that leads to an increase in labor to obtain the same or even lower returns. Despite this classic understanding of intensification, many other archaeologists understand it as increased efficiency. There are three ways to be efficient: diversification, specialization, and innovation (Morgan 2015).

Within OFT models, the diet breath model is among the most used and helps to examine the decisions foragers do at the moment to pursue or capture a prey (Winterhalder and Smith 2000). The diet breath model has its foundation on two components of foraging: search and handling. Search refers to the time a forager needs to find prey, weather by direct (visual contact) or indirect (traces on the ground) encounter. Handling refers to the time (or, less commonly energy) of the tasks required to pursue and process that prey (Bird and O'Connell 2006). The number of calories and the handling cost impacts the profit of prey species. Therefore, to determine and calculate a net rank of a prey species, we must consider both the caloric value and its handling cost. The diet breath model has been helpful to study the process of intensification because it allows to detect when the ranks of resources change and how these changes are related to new pursuing or handling costs regarding one species (Bird and O'Connell 2006). At the same time, it allows to detect why some new resources that are added to the diet involve technological changes that pay off the investment and higher handling cost by increasing the return of certain resources (Morgan 2015). For example, the incorporation of ceramics can allow to increase the return on certain seeds through more efficient ways of boiling and reducing wood needs. Thanks to that technology those seeds gets a higher rank within the resources to be exploited.

If we set aside the common assumption that larger animals provide more calories, we may find that while considering handling costs, many returns are negatively correlated with carcass size. For example, in Mendoza armadillos (*Zaedyus pichiy*), have high return rates. Though they weight only 1-3kg, being one the smallest animals available, they are quite easy to capture and cook (Otaola et al. 2015). Furthermore, on average rheas (*Rhea pennata, Rhea americana*) weight

14 kg, but are very difficult to capture. However, rhea eggs (available only in the spring), are very easy to collect with little handling costs (Giardina et al. 2014). Additional information from stable isotopes can reveal patterns both in diet and mobility.

Neme and Gil (2008a) identify a process of intensification in southern Mendoza in the Late Holocene, 2000 years BP, that involves exploitation of a wider and more costly range of plant and animal resources. In addition, they suggest that increasing use of non-local obsidian might reflect a tendency towards territoriality and inter-group exchange. Further evidence for economic intensification includes the sudden incorporation of ceramic technology and stone tools designed specifically for exploiting small game. The incorporation of ceramic vessels demands more investment compared to the use of basketry and leather bags (Eerkens 2008). In mobile societies, use of ceramics may be problematic if the manufacturing process interferes with residential movements and the acquisition of seasonal resources, for example when the vessel drying and firing process requires foragers to stay in places for longer periods of time. Yet the potential merits of ceramics to the subsistence system may include improved return rates on seed crops and animal products like bone if cooking releases more calories relative to the time invested in their acquisition (Bettinger et al. 1994, Sturm et al. 2016). Specific dissertations about technology, resource exploitation, resource availability, and post-depositional decay discuss the process of intensification with varied results (Andreoni 2014; Giardina 2010; Llano 2011; Otaola 2013; Salgán 2013; Corbat 2016; Fernández 2010; Sugrañes 2016; Garvey 2012). The analysis of fauna warns about the trends of using data from different ecological zones to generate conclusions at the regional scale. I consider that a more intensive use of the Highlands during summer, in the context of complementary use of land across the Diamante valley was immersed in the context of intensification as have been proposed for southern Mendoza (Neme and Gil 2008a; Neme 2007).

1.4 **Research questions**

To contribute to the research agenda of human adaptations to marginal environments that attempt to: explore when and how effective occupation of the landscape occurred in different regions; compare among different trajectories of adaptations and their variability; and investigate the role of technology in the subsistence systems to manage resources stress, I propose the following specific research questions:

1.4.1 **Were the Lowlands, the Piedmont, and the Highlands occupied with the same intensity?**

I would expect that the use of space differed in the three ecological zones. The Piedmont and the Lowlands, occupied throughout the whole year, should have higher densities of materials than the Highlands. Many authors (Gil et al. 2014; Williams et al. 2015) use site counts and radiocarbon dates as population proxies to address changes in the balance between population and resources. My approach is to measure the intensity of land use by recording the proportion of units occupied by human groups in three ecological zones (Drennan 2009; Drennan et al. 2015). Evidence for human activity (both in terms of the distribution of artifacts and sites) should be more clustered in the Highlands and more diffuse in the Lowlands as resources are more evenly distributed (i.e. less “patchy”) at lower elevations. In the Highlands, which are accessible only in the summer, materials should be concentrated in fewer places because people reoccupied the same places for shorter periods of time, and focused on a narrower range of resources. There I should find higher rates of non-local raw materials, millings stones, and ceramics that are cached and reused. In the Piedmont I should find concentrations with moderate clustering, and higher variability depending on different special tasks such as gathering, hunting or procurement of local raw materials. In the Lowlands I expect to find sites with similar sizes, evenly distributed across the riverside due to a more homogeneous distribution of resources.

1.4.2 **Does site structure reflect uses specific to the different ecological zones?**

By site structure I refer to the variation in the characteristics, amount and densities of archaeological materials found among assemblages. The variability of sites within each ecological zone should relate to the functional diversity of these settlements. The size of an assemblage usually correlates with the diversity of categories within it (Bettinger et al. 1994). This means that larger sites will tend to show higher diversity of artifacts types. The next step is to assess if the proportions of certain categories remain constant both in small and large sites. There might be three reasons for difference among assemblages: 1) site function; 2) cultural diversity; and 3) temporal change.

In the Highlands I expected: 1) Base camps with large site areas and both high artifact diversity and frequency; and 2) Special use hunting sites with low artifact frequencies. In the Piedmont I should find: 1) Primary base camps with moderate site areas and higher artifact diversity and frequency than in secondary base camps; and 2) Special use sites reflecting discrete activities such as hunting, gathering and quarrying. In the Lowlands, I should find base camps with similar size and diversity of tools.

1.4.3 **How did people used mobility to manage the landscape of the Diamante valley?**

Mobility is the main strategy that hunter gatherers use to move people to resources, and resources to people (Kelly 1983, 1992, 1995). Movements and resource acquisition throughout the year will vary in each ecological zone in response to heterogenous resource structure. Binford (1978, 1980) defined residential mobility as the movement of families, groups, or bands from one camp to another. He also defined logistic mobility as task trips or foraging movements from and to the residential bases. From ethnographic observations, he proposed that some hunter gatherers have a forager mobility strategy that implies many movements across the landscape with few logistic trips and storage. Conversely, other groups have a collector mobility strategy that implies settling close to a reliable source of water and a rich patch of resources, while doing logistic trips to bring resources to the base camp. Importantly, the difference between foragers and collectors is not only related to the length or duration of movements. Instead, the social organization differs as foragers privilege the movement of groups, while collectors rely more on the movements of individuals (Kelly 1992).

Because stone tool technology is organized around different kinds of mobility strategies, quantitative analysis of the lithic remains of that technology can be used as a proxy for hunter-gatherer mobility (Parry and Kelly 1987; Andrefsky 1994). The different proportions of local and non-local raw materials, cores and tools in each ecological zone and archaeological site will reveal different mobility strategies related to the organization of lithic technology across the Diamante valley.

The percentage of cortex for debitage and other artifact types can be used as a way to measure proximity to places where raw materials are acquired, and to assess the intensity of use in the manufacturing sequence (Salgán 2013). Cortex can be produced by chemical and mechanical weathering, as a result of the exposure of the rock to atmospheric conditions such as moisture and heat, and by the transport that naturally occurs in the landscape—for example, when a nodule has been rolled by a river (Andrefsky 1998). Therefore, we can assume that cortex is the first area removed during tool production or core reduction (Andrefsky 1998). The amount of cortex will depend on the technique used, the particularities of the rock, and the type of tool that is being produced. By identifying different percentages of cortex, I would be able to detect which places were used for raw material procurement, how rocks circulated to the places of final use and discard, and how rocks were managed in relation to their availability and importance in the landscape and subsistence system. Finally, by percentage of cortex, I refer to the amount of cortex that covers the dorsal face of a piece. Zero percent is when no cortex exists, and therefore is an indicator of advanced stages in the reduction sequence—the steps during tool manufacturing from thinning a blank until a finished tool is produced. One to fifty percent is when cortex covers almost half of the piece; this percentage is frequently found in intermediate stages of the manufacturing sequence. And finally, 100 percent is when all the dorsal face of the piece is covered with cortex; this is an indicator of initial stages of a core reduction—this kind of evidence can allow us to infer raw material acquisition.

In the Highlands, the lithic organization will show lower cortex percentages, reduced frequencies of cores in an exhausted state. Surovell (2012) proposes that is possible to measure the length of time that people spend in any given location by analyzing its lithic assemblage. The ratio of local to non-local raw materials can be used as proxy of the duration of occupation. When people move away from one place, they bring with them the local materials from that place; when they arrive in a new place they introduce those non-local raw materials to it; and as they spend more time in the new place, more of their tools will be made from local raw materials. In addition, we can also measure the ratio of debitage to tools in non-local raw materials as a complementary proxy of the degree of permanence at a given location (Surovell 2012).

Garvey (2015) states that obsidian played a key role in the occupation of the Highlands due to the proximity to some sources. In southern Mendoza, there are five known obsidian sources. Two of them, Las Cargas and Laguna el Maule, show evidence of use throughout the Holocene. El Peceño, Cerro Huenul and Laguna del Diamante show evidence of use only during the Late Holocene (Cortegoso et al. 2012; Garvey et al. 2016). All of them should be considered non-local sources as they are located further than 30km from the survey areas. The assignment to local and non-local lithic raw materials is an arbitrary decision that should be explicit. I follow the approach used for lithic studies in southern Mendoza, in which less than 30km away from a source is considered local and beyond it is considered non-local (Salgán 2013).

In the Highlands of the Diamante valley I expect that obsidian would have been acquired from the closest sources, such as the Laguna del Diamante. I would expect larger proportions in places with evidence of persistent occupations, with indication of exhausted cores, and few percentages of cortex showing maximization in the use of this resource during transport.

1.4.4 How was ceramic technology used in the three ecological zones?

Hunter-gatherers face many constraints when considering the use of ceramic technology: 1) the utility and costs of similar technologies such as basketry and leather bags; 2) fragility of the pots and whether or not they can be moved between residential and/or logistical camps; 3) scheduling conflicts between ceramic production and other activities such as seed gathering; and 4) small scale production do not take advantage on the opportunity to fire large amounts pots at the same time (Eerkens 2003, 2008). Ceramics first started to appear in southern Mendoza around

2,300 years BP (Lagiglia 1997; Neme 2007). In addition to learning why and when this technology was acquired, we can explore how hunter-gatherers manage the costs of producing and transporting this technology in light of their seasonal constraints, movements, and needs. Variation in ceramic use across settlement systems permits investigation of patterns of mobility and seasonality. To interpret such variation, we need to consider the differences among the ecological zones and their limitations, the energy spent in manufacture, the utility of the vessel, and the duration of their use.

If we assume that more people staying for longer periods of time will leave more artifacts behind, then base camps will present higher absolute abundance of artifacts in comparison to short-term sites. Higher relative abundance of ceramics relative to lithics, should reveal the relative importance of this technology in food processing and storage. This accords with the model proposed by Sturm et al. (2016), in which low investment is expected in summer aggregation sites and high investment is expected for winter camps. If ceramics were more important in some of the ecological zones, I expect to find different relative proportions of lithics and ceramics. In the summer camps of the Highlands, ceramics will be rare, and the investment in their manufacture will be minimal. In the Piedmont and the Lowlands, there will be two kinds of settlements: those with few but inexpensive ceramics, and those with many costly ceramics, depending on the expected use time of ceramics at those locations (e.g. less investments of pots in special task camps with short stays, versus more investment in base camps with longer stays). Assemblages from the Highlands of the nearby Atuel valley show a higher proportion of ceramics to lithics compared to sites from other ecological zones (Neme 2007). To explore the degree of investment in ceramics production, I will focus on 4 variables based on these expectations: finer wall thickness demands more work as the piece gets more fragile and unstable during manufacture; finer and homogenous temper size implies some extra work in selection of temper before being added to the clay; reduced firing implies special techniques and care to reduce the oxygen in the atmosphere during the process; and smoothing is the most common and inexpensive surface treatment, as opposed to brushing and polishing. Vessel thickness, temper size, firing and surface treatment, should show low investment for the sites of summer aggregation in the Highlands and high investment for the sites in the Piedmont and the Lowlands (Franchetti and Sugrañes 2012).

My research focus is to investigate how hunter-gatherers from northern Patagonia complemented the use of land across different ecological zones to mitigate risk in the context of aridity and high elevation environments. Through the study of settlement patterns, the organization of lithic technology and the use of ceramics I plan to determine how different strategies permitted the adaptation to different ecological zones.

1.5 **Contribution**

The results of this dissertation are structured in four major blocks: Settlement patterns at the scale of the ecological zones, internal variability of archaeological sites, chronology insights in distributional archaeology and fieldwork assessment. This study is framed in the many efforts to learn about human adaptation to environmental variation and change. Adaptation as a concept and process involves understanding how human populations used different strategies to survive and reproduce and is particularly suitable for problematizing the use of marginal environments (both arid and high elevation). Through insights of different trajectories, we are able to trace patterns, elaborate generalizations and explain change and stability among the particularities and diversity of human practices and behavior. This research will help to demonstrate different uses of space in the arid lands of northern Patagonia. By the analysis of distribution, density and characteristics of lithics and ceramic materials, this study focuses mainly in the role of mobility, land use, and technological change. It complements other studies of resource exploitation that focus on the analysis of plant and animal remains (Neme and Gil 2008b; Otaola et al. 2015).

Finally, this contributes to the study of the different strategies used by human populations to mitigate risk by managing different ecological zones at different seasons of the year in a context of extreme aridity and moderate high-altitude at southern latitudes. The focus will be to examine how the settlement patterns differ in the Highlands, the Piedmont, and the Lowlands. The distribution of settlements changed in the three ecological zones, allowing a more regular use of marginal areas (high elevations and low productivity deserts, namely, the Lowlands). The role and functions of ceramics in this context would help to understand the changes in subsistence and social relationships in which they were incorporated. The analysis of lithic technology will clarify mobility and network patterns. The aim is to improve the understanding of human adaptations worldwide and to enable comparative analysis of similar evolutionary phenomena known from regions faced with similar constraints and challenges, such as the American Great Basin, Australia, South Africa, and perhaps Tibet.

2.0 The environment

2.1 **Deserts of southern Mendoza**

Central and southern Mendoza province, located between 33–37° S and 70–67° W, is characterized by its environmental diversity. Three main rivers irrigate the region: the Diamante, the Atuel, and the Grande. Three different sub-environments differentiate according to altitude: the Highlands, the Lowlands, and the Piedmont. The availability of plant, animal, and water resources varies among them. Rainfall ranges from 900 to 300 mm annually, creating semi-arid climate conditions. Humans inhabit elevations from 700 masl in the Lowlands to 3,600 masl in the Highlands (Neme 2009). During the summer, water is abundant in the Highlands but scarce in the Lowlands. While plants are more abundant in the Lowlands, large animals are more abundant in the Piedmont though they move seasonally to the Highlands in summer and to the Lowlands in winter (Table 2.1). Seasonal variation is explained by elevation and continental conditions. The Diamante valley´s phytogeography is in a transition between Patagonia, Monte, and Altoandina phytogeographic provinces (Cabrera 1976; Roig 1972; Mares et al. 1985).

There are two areas that have a few specific characteristics within southern Mendoza, these are Llancanelo and Payunia. Llancanelo is a sedimentary geoform at 1,400 masl that includes saltworks and a homonym lake. This area present alluvial and piedmont deposits. The water from the lake is brackish but many streams flow into it in the northeast sector. Payunia is a plateau situated between 1,700 and 2,000 masl, with more than 700 volcanos which are mainly inactive. There are very few permanent water sources, and during some periods of the year, water from rainfall accumulates in land deflated sections forming ephemeral reservoirs.

2.2 **Geography**

There is a major change in the Andes between 33° and 37° latitude, a decrease in the mean and high peak elevation, as well as a decrease in the mountain width range. This coincides with the changes in the angle of the subducting slab, producing a switch from 10° in the north to more than 30° in the south (Baker 2005). This has a major impact on earthquake activity in the north and volcanic activity in the south that relates to arc and back-arc plaque dynamics (Baker 2005). In addition, this influences the localization of most of the obsidian sources in sourthern Mendoza as well as many basalt outcrops across the Diamante valley (Salgán et al. 2012).

The Diamante River discharge is markedly seasonal, with more than 40m3/seg from November to February (Figure 2.1) (Boninsegna and Villalba 2006). From the Diamante lagoon, the Diamante river has five tributaries in the Highlands: the Barroso, the Borbollon, the Bravo, the Blanco, the Negro, and the Aucas. The geomorphology of the Highlands is marked by glacial geoforms such as moraines, cirques, and lakes. During the last deglaciation, the Diamante river transported glacial meltwater and sediments downstream.

In the Piedmont the tributaries are the Carrizalito, the Hondo, the Faja, and the Tigre. Between the Piedmont and the Lowlands, there is the San Rafael basement block, situated 40km east of the Cordillera. This block is composed by metamorphic, sedimentary and volcanic rocks from the Paleozoic and the Triassic. It was uplifted during the Miocene by the Andean deformation. Its main effect on the Lowlands is the generation of mild weather conditions due to the barrier it sets to west winds. In the Lowlands, the Hedionda and the Chanchos streams create well-developed fill terraces and alluvial floodplains. The Diamante river becomes a tributary of the Desaguadero-Salado fluvial system (González Díaz 1972; Tripaldi et al. 2011).

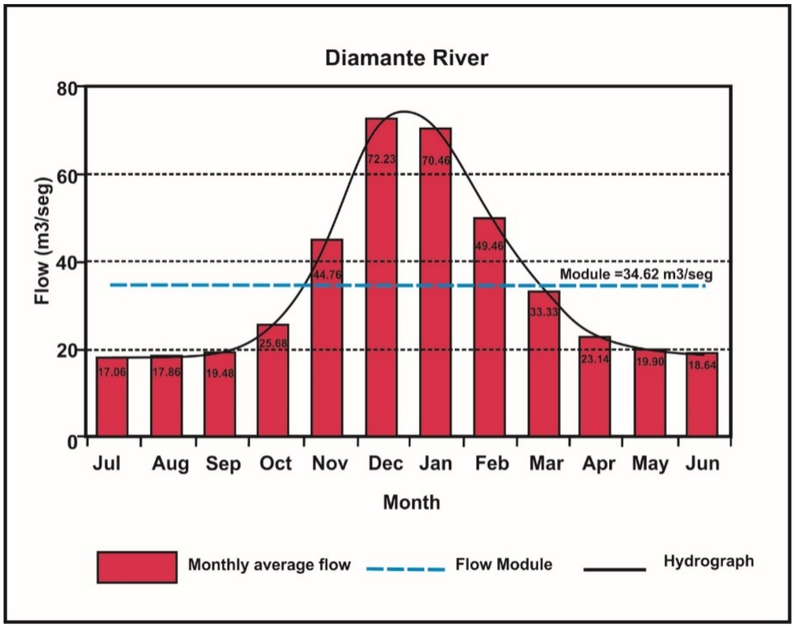

Figure 2.1 Monthly river flow (m3/s) of the Diamante River averaged during the period 1946-1994. Figure modified from Boninsegna and Villalba 2006.

2.2.1 The Highlands

Different authors agree that adaptive problems begin at an altitude above 2,500 masl (Aldenderfer 1998; Neme 2007; Beall 2013; Barton 2016). The study of human adaptations to altitude stress in northern Patagonia depends on two different altitudinal gradients (Table 2.1). The intermediate valleys reach elevations up to 3,000 masl, and there are locations above 3,200 masl associated with high altitude villages with stone structures (Neme 2016; Morgan et al. 2017). This research mainly focuses on the study of a portion of the intermediate valleys of the Diamante valley, between 2,000 masl until 3,300 masl. The Highland biogeographic area corresponds to the headwaters of the Diamante River. Elevation ranges from 2,000 to 5,000 masl. The Diamante River itself begins in the Diamante lagoon, at 3,200 masl. Most locations situated on average above 3,700 masl are currently covered by permanent snowfields or glaciers. This affects the geomorphology of the landscape in the area. In addition, latitude is a factor that affects the harshness of altitude; those elevated areas closer to the equator have better conditions for human living (Neme 2007). Most importantly, elevation influences precipitation, temperature, flora, and fauna (Capitanelli 1972). The climate conditions are shaped by the Pacific anticyclone, allowing 900mm of precipitation, mostly as snow during winter (González Loyarte et al. 2009). The average annual temperature differs at different altitude levels: at 2,000 masl it drops to 9°C, and at 3,000 it drops to 0°C (González Loyarte et al. 2009).

Table 2.1 Main environmental characteristics of the biogeographic units of the Diamante River valley.

Biogeographic Unit	Variations	Phytogeographic unit	Zoogeographic Unit	Altitude masl	Temperatures	Precipitation
Highlands	High Summits-High elevation plains	Altoandina	Andino-Subandino	3000-5000	Ave. 0°C Max 25°C	900mm (snow)
	Intermediate Valleys-Vegas	Altoandina	Andino-Subandino	2000-3000	Ave. 9°C Max 30°C	
Piedmont	Ecotone	Patagonica - Monte	Patagonico	1900-900	Ave. 12°C max 38°C	220mm
Lowlands	Monte	Monte	Subandino-Pampeano	900-300	Ave. 15°C max 37°C	300-400mm
	Espinal	Espinal	Subandino-Pampeano	700-300	Ave. 15°C max 37°C	400-450mm

2.2.2 The Piedmont

The Patagonian desert is an ecotone between the Monte and Patagonian phytogeographic provinces. The altitude ranges from 1,900 to 1,000 masl. Average temperatures in summer are 22°C and in winter 5°C. Precipitation averages 220mm/year with maximum values reaching 280mm/year. The distribution of rainfall is consistent throughout the year, as this area is influenced by both Pacific and Atlantic anticyclones (De Marco et al. 1993).

2.2.3 **The Lowlands**

The Lowlands are plains characterized by a mean annual rainfall of 350 mm and mean temperatures of 15°C, the maximum average temperature reaching 37°C. Due to the altitude of the Andes, 5,000 to 6,000 masl in this latitude, no winter rain reaches the area. Instead, the Atlantic anticyclone dominates the climatic conditions with summer storms. Geomorphologically, the Lowlands is an extensive aggradational environment, composed by fluvial and aeolian deposits visible along riverbanks. In addition, extensive and complex dunes cover the eastern section of the Lowlands towards the Desaguadero River (Tripaldi et al. 2010). The elevation ranges from 900 to 350 masl in the east. The Lowlands are dissected by two ephemeral streams called the Hedionda and the Chancho.

The boundaries of this area in relation to the phytogeography can present some ecotones. Towards the west, the limits depend on the topography of the Andes; to the east the transitions occur by the rainfall gradient, which increases eastwards. The Atlantic anticyclone influences the Lowlands, generating precipitation in summer. Therefore, to the northeast there is an ecotone with the Chaco province and to the east with the Espinal province (Abraham et al. 2009).

González Loyarte et al. (2009) create a model map based in NDVI images in which they confirm a homogenous continuum among different bioclimatic areas of the Monte. It is worthwhile to mention that they present historic data for average precipitation in Mendoza during the first and second half of the twentieth century, showing an increase of 70 mm during the second half. 71-76% of the precipitation in the semiarid deserts was concentrated during October-February. For the Lowlands of the Diamante valley, they identify two different semiarid deserts: the inferior covers 25% of the Lowlands (300-400mm average rainfalls) and the superior covers 27% of the Lowlands (400mm average annual rainfall); 50% of the years it rained more than 400mm, and less than 20% of the years it rained more than 500mm. In terms of thermal stress, the ratio between precipitation and potential evapotranspiration ranges from 0.05 to 0.5, which points to a water deficit for the entire area (Labraga and Villalba 2009).

2.3 **Resources: flora and fauna**

Associated with the production of vegetal coverage, primary productivity influences the faunal and floral communities in the three biogeographical zones. Primary productivity can be negatively affected by evapotranspiration and water percolation (Rosenzweig 1968). The composition of resource structure can also be affected by other variables such as annual precipitation and the capacity of soils to retain water (Rosenzweig 1968). For example, annual precipitation is higher in the Altoandino desert, where water is retained only in springs, which are attractive to both animals and humans. Three main phytogeographic provinces comprise the flora from of southern Mendoza: the Altoandina, the Patagonica, and the Monte. Zoogeographically, Mendoza province belongs to the Neotropical Region. Roig (1972) describes 4 districts for Mendoza Province: the Andino, the Subandino, the Patagonico, and the Subandino-pampeano.

2.3.1 **Flora**

The Monte phytogeographic province is related floristically to zones from North America that contain *Larrea*—a genus of flowering plants, evergreen shrubs. The most important genera present are *Prosopis*, *Cercidium*, and *Larrea*. More than 15 species in the Monte are endemic to both South and North America, including: *Capparis atamisquea, Setaria leucopila, Trichloris* *crinita, Scleropogon brevifolius, Sporobolus cryptandrus, Verbesina encelioides, Bouteloua aristidoides* and *Diplachne dubia*. However, the major resemblances occur at the level of Gramineae. Roig et al. (2009), discuss four different hypotheses to explain the similarities of desert flora that are 9,000km apart: 1) a transcontinental desert that was once connected in the past; 2) existence of ecological corridors between them; 3) long distance dispersion; or 4) common ancestors and convergent evolution.

The most common plants in the Patagonian desert are steppe shrubs, grasses, and cotyledons. In addition, steppe grasses are near areas of greater humidity. Adjacent to water streams, some elements of the Monte phytogeographic province produce an ecotone (Cabrera 1976).

Cabrera (1976) describes low shrub (Asteraceae) and steppe grasses (Poaceae) as the main flora in the Altoandean phytogeographic province. Yellow wood, also known as leña amarilla (*Adesmia pinifolia*), is frequent between 2,000-3,400 masl and is a good source of firewood. Other common species in the Altoandean province are pataguilla–colimamul (*Anarthropphyllum rigidum*), molle (*Schinus odonellii*), and acerrillo *Adesmia subterranea* (Roig 1972). Species suitable for human exploitation available on hill slopes include: calafate (*Berberis empetrifolia*), molle (*Schinus odonellii*), alelíde las sierras (*Rhodophiala tuberosum*), and porotera (*Senna arnottiana).* The most common vegetation community is the coironal, which is dominated by *Pappostipa chrysophylla* (Cabrera 1976).

2.3.2 **Fauna**

The main faunal resources in the Highlands are the guanaco (*Lama guanicoe*); the puma, one of the South American lions (*Puma concolor*); and the red fox (*Pseudalopex culpaeus*). In addition, there are lizards (*Liolaemus elongatus*), armadillos (*Zaedyus pichiy; Chaetophractus villosus*), and small rodents (*Akodon andinus, Ctenomys mendocius and Phyllotis darwini*). Some waterfowl species (e.g., *Anas* sp.) migrate on a regular basis to high-elevation lakes (Roig 1972). Moreover, the scarcity of faunal resources is accentuated between 3,000-4,500 masl, where resources are mainly confined to vegas—patches rich in water availability, as well as plants and animals, above 2,000 masl.

In the Piedmont, below 2,300 masl, the red fox is replaced by the grey fox (*Pseudalopex griseus*); the guanaco and the puma are still the largest mammals present. In this area we also find medium-sized rodents such as the chinchillón (*Lagidium viscaccia*) and the Vizcacha (*Lagostomus maximus*), and other rodents less than 1 kg., like the Tuco-Tuco (*Ctenomys mendocinus*). There are also live edentates, such as the big hairy armadillo (*Chaetophractus villosus)* and the dwarf armadillo (*Zaediyus pichiy)*, and carnivores such as the wild cat (*Felis geoffroyi*) and the skunk (*Conepatus chinga*).Though there are many birds that frequent the region, among the most important to people is the rhea (*Rhea americana*), which are located in well-defined niches within this ecological zone (Roig 1972). It is also possible to find saurians, including batrachians and reptiles. The fish native to this area are the bagres (e.g. *Hatcheria macraei)* (Roig 1972). Despite this large list of native species, the zooarchaeological record is dominated by guanacos, edentates, and large-sized rodents such as the Patagonian Mara, the Chinchilla, and the Vizcacha (Neme 2007; Otaola et al. 2015). Due to the lack of optimal conditions for the generation of soils and moisture to let vegetation grow continuously, the middle (Patagonia desert) and upper basin (Altoandino desert) present a patchy distribution of resources (Roig 1972; Neme 2007; Morgan et al. 2017).

The guanaco is the main herbivore of the Andean steppe, playing a central role in arid ecosystems. It has social behavior and forms groups of families or single males; and sometimes there are isolated males who keep a distance from the larger group and function as sentries. The populations can be sedentary or migratory (Franklin and Fritz 1991), which may have a major impact on hunting strategies. They can weigh between 100-120kg; they are gregarious, diurnal herbivores and opportunistic feeders. They adapt to environmental change by shifting their diet from herbaceous strata to shrubs or tree strata (González et al. 2006; Puig et al. 1996). This also translates to their flexibility to migrate seasonally if necessary, generating a wide range of mobile-sedentary populations. For example, in Payunia the home range goes from 130 to 220 km^2 (Carmanchahi et al. 2014).

There are two rhea species present in southern Mendoza: *Rhea americana* inhabits areas below 1,200 masl, typically grasslands (Canevari et al. 1991); *Rhea pennata* inhabits areas below 1,500 masl, typically steppes and shrublands (Bellis et al. 2006). Both species are generalist omnivores that subsist mainly on plants (Hoyo et al. 1992). In southern Mendoza *R. americana* inhabit the Lowlands while *R. pennata* inhabit the Piedmont. Both rheas have the same nesting behavior: the female produces close to 20 eggs annually, during the 90 days of spring, and shares the nest with other females (Giardina et al. 2014); the male remains in the nest until the chicks hatch. On average, a nest can hold 25-40 eggs, which implies around 21,000 kcal, at a rate of 630kcal per egg—an amount approaching the 24,000 kilocalories that an entire animal has (Giardina 2006).

Piche armadillos (*Zaedius Pichiy)* – also known as dwarf armadillos–are present in the provinces of Mendoza, San Luis, and Buenos Aires, between south of the Santa Cruz River and the Strait of Magellan in Chile (Wetzel 1985). They inhabit open lands and firm sandy soils. With a body weight of 1-2.3kg (Canevari and Vacaro 2007), they live mainly in solitude and diurnally on a generalized carnivore-omnivore diet that consists mainly of insects (Superina et al. 2009). They are easy to capture, process, and cook; they are very tasty and quite greasy.

2.4 **Paleoenvironment**

The paleoclimatic of southern Mendoza have been established through a variety of environmental proxies, which illustrate successive changes since the beginning of the Holocene (Markgraf 1983, 1989; D'Antoni 1983; Lagiglia 1970; Stingl and Garleff 1985; Espizúa 1993; Heusser 1983; Villalba 1990; Schäbitz 1994). The studies of glaciers in central Chile indicate a glacial development before 13,000 years BP, followed by a rapid deglaciation ca. 12,500 years BP (Mercer 1983, 1984).

Markgraf (1983) elaborates a paleoenvironmental chronology between 32º and 35º S from palynological studies. In addition, the results from microvertebrate analysis confirm the same paleoenvironmental changes (Neme and Gil 2002). The inferences for the last 14,000 years are:

1) A relevant change towards 12,000 years BP that evidences a shift from a patagonic grassland to a stumpy-shrub desert. These changes, according to the author, were due to a shift from a climate dominated by winter rains to one dominated by summer rains and temperatures similar to modern times.

2) Between 8,500 and 5,000 years BP, the summer rains that gave identity to the early post-glacial stumpy-shrub desert diminished considerably. This period may have involved extreme aridity with temperatures much higher than today (Markgraf 1983; 1989).

3) Between 5,000 and 3,000 years BP there was a precipitation increment and lower temperatures. These conditions lasted until 3,000 years BP, when modern climatic conditions emerged with higher frequencies of summer rains and higher temperatures (Markgraf 1983, 1989).

D'Antoni (1983) argues that the most important environmental change over the last 30,000 years occurred around 10,000 years BP, when the flora of the Patagonian phytogeographic province gave way to the vegetation of the Monte in the Lowlands.

Villalba (1990) reports dendrochronological studies for northern Patagonia and Central Chile during the Late Holocene, specifically for the last 1,000 years BP. This high resolution paleoclimatic sequence intercalates cold-humid and hot-arid periods. The cold periods are 1,100-930 years BP; 730-620 years BP; and 480-330 years BP; with peaks of lower temperatures between 660 and 350 years BP. In contrast, the warmer and drier periods are 920-720 years BP; 315-230 years BP; and a short period,140-110 years BP.

In sum, deglaciation occurred around 12,000 years BP; there is a major change around 8,500 years BP, with increased aridity produced by more winter rains, lower temperatures, and diminished summer rains; and finally; and by 3,000 years BP the climatic conditions were similar to modern times (Lagiglia 1970, Markgraf 1983; D´Antoni 1983).

2.5 **Lithic resources**

Between 33° and 39°S the Andes contain sources of volcanic tool-stone in arc and backarc settings that are located at high altitudes as well as in the eastern plains (Baker 2005; Cortegoso et al. 2012). There are five obsidian sources identified in southern Mendoza: Laguna del Maule, Las Cargas, Laguna el Diamante, El Peceño and Cerro Huenul (Cortegoso et al. 2012) (Figure 2.2).

The first three sources are accessible only during the summer while the last two are available throughout the year; topography affects access to the five sources. Researchers are also working to explore and understand at least three other obsidian sources: Payun Matru, Zaino and Coche Quemado (Figure 2.2) (Salgán and Pompei 2017).

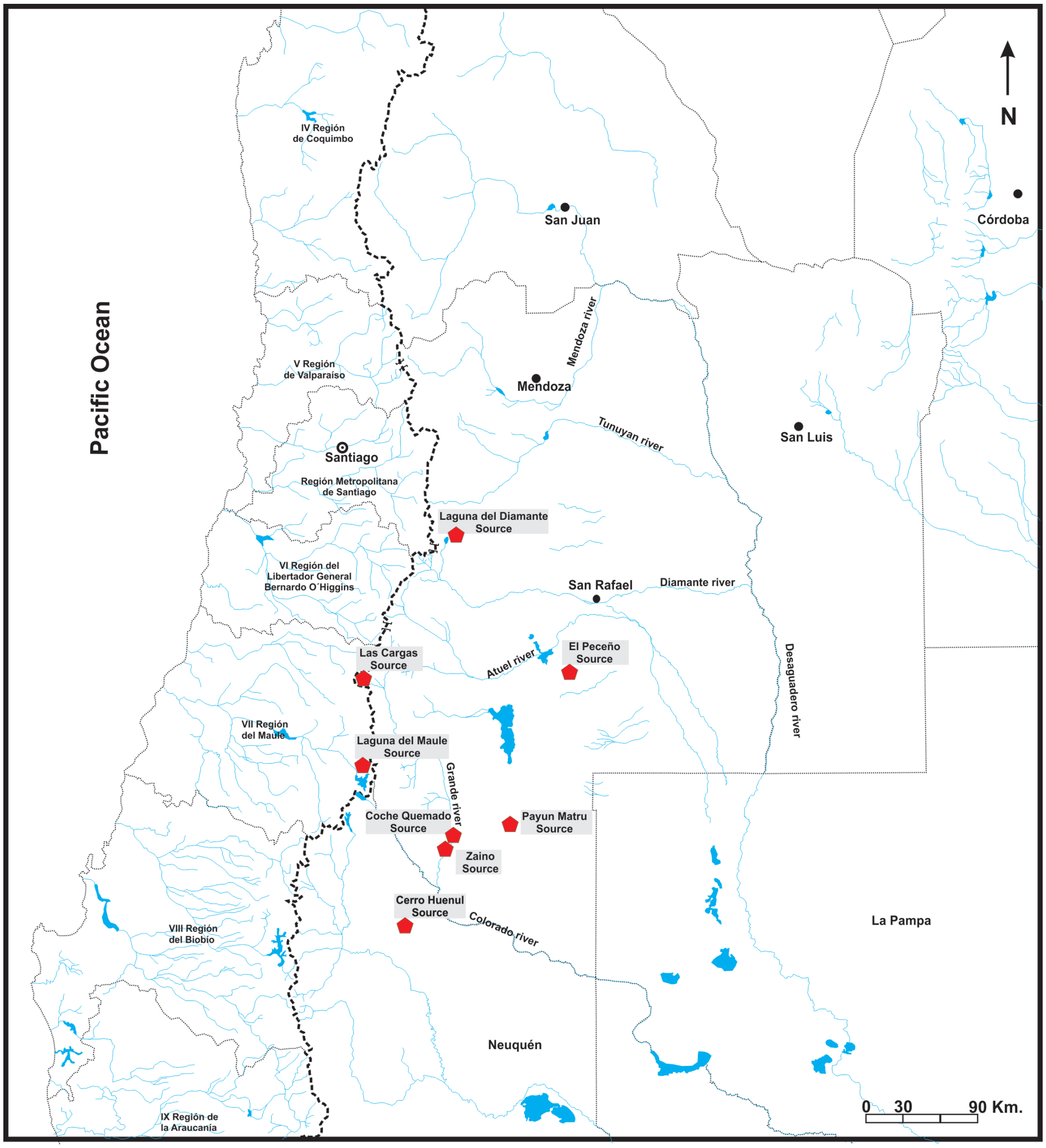

Figure 2.2 Location of obsidian sources from southern Mendoza marked in red. Figure modified from Salgán and Pompei (2017).

2.5.1 **Andean obsidian sources- summer availability**

Laguna del Maule, which covers more than 900km^2, is the largest obsidian source in the region (Salgán et al. 2015). Combining the localities of Laguna Negra and Arroyo Pehuenche, it is located at 2,400 masl on the border of Argentina and Chile. Its nodules and blocks are of excellent quality and reach sizes of up to one cubic meter. The nodules of Arroyo Pehuenche are smaller, between 3 and 5 cm, suggesting alluvial transport and redeposition.

Salgan et al. (2015) characterize Las Cargas as an obsidian source located on the border of Argentina and Chile (35° 11' S, 70° 25' W; 2,600 masl). This source rests on the banks of the Cura stream, a tributary of the Grande river. It covers 1km^2 though some nodules have been found 4km downstream. Different qualities of obsidian are present for tool manufacture.

Laguna del Diamante is located at 3,200 masl in a volcanic caldera the upper valley of the Diamante river. It presents nodules not larger than 10cm as well as ignimbrites that are distributed across the nearby slopes up to 3,800 masl. While the quality of obsidian is good, it appears fragmented and in low frequency (Giesso et al. 2011).

2.5.2 **Extra-andean sources, year-round availability**

The El Peceño obsidian source in the eastern plain of Mendoza is next to the El Nevado volcano at 1400 masl. Nodules can be found up to one kilometer away from the cone; their sizes range from 2 to 30cm. The quality and abundance of obsidian is very good (Giesso et al. 2011; Salgán and Pompei 2017).

Huenul is an obsidian source located next to the Colorado river at 900 masl (Giesso et al. 2011). Additionally, alluvial processes have redeposited the nodules several kilometers away; their sizes are small and medium, up to 10 cm in diameter. The raw material is of good quality and abundant. In some places, a person can collect 50kg of obsidian in one hour (Giesso et al. 2011).

2.5.3 Basalts, cryptocrystallines, and other raw materials

Basalts, cryptocrystallines, and other raw materials are locally abundant in the Piedmont and the Highlands. The geologic sheet 3569-I “Volcan Maipo” describes exhaustively the formations from the Paleozoic to the Quaternary (Sruoga et al. 2005). It highlights the presence of basalts in numerous formations. For a clear overview of the availability of this raw material, I marked the locations with this raw material in grey (Figure 2.3). Note the extremely large source of basalt at the east of the Piedmont (Figure 2.3). Both cryptocrystalline and other raw materials are categories that encompass many types of rock, and therefore their presence is product of a mix of complex geologic processes across different periods. Both from the Volcan Maipo geologic sheet and from the field observations, we can be certain of their local availability and their use in the Highlands and the Piedmont across the Holocene.

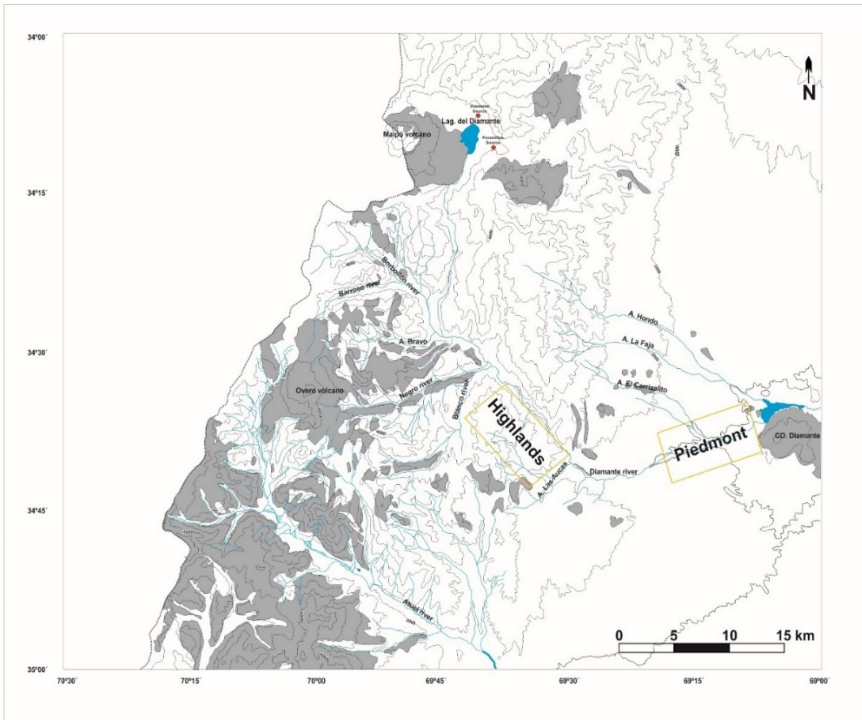

Figure 2.3 Extension of areas with basalts availability (in grey) based on 3569-I "VolcanMaipo" geological chart. Red dots indicate the location of Laguna del Diamante and Paramillos obsidian sources. Figure modified from Sruoga et al. (2005).

In summary, the ecological zones selected for this dissertation reflects the intersection of Phytogeographic provinces (Altoandina, Patagonia and Monte), with zoogeographic provinces, linked to the impact that altitude and geomorphology have in the distribution of plants and animals. These ecological zones manifest ecotones in transitional areas. The main faunal resources were guanaco *(Lama guanicoe),* rhea *(Rhea pennata)* and armadillos (*Zaedius Pichiy)*. The main plants collected were piquillín *(Condalia microphylla),* chañar *(Geoffroea decorticans)* and algarrobo *(Prosopis flexuosa).* The paleoenvironment during the last 10,000 years BP indicated the transition between the retraction of glacial in the Pleistocene-Holocene transition, a period of extreme aridity between 7,000-5,000 years BP, and the stabilization of climatic conditions similar to modern times in the last 4,000 years BP. Lithic resources were heterogeneously distributed in space, basalts and cryptocrystallines can be considered local in the survey area. There are 8 obsidian sources that have been detected and described in Mendoza province, both in andean and extra-andean localities.

3.0 Archaeological and ethnographic background

3.1 **Cultural history and evolutionary ecology**

The first systematic archaeological studies in southern Mendoza were made by Humberto Lagiglia in the 1960's. Following a cultural historic approach, he based the chronology and description of past human groups on the excavation of the "Gruta del Indio" archaeological site. Lagiglia (1977a) produced the first systematic studies in the region with descriptions of ceramic styles along with early botanic studies. He established the cultural sequence of southern Mendoza, outlining four periods (Atuel I-IV), but his work lacked the analysis of archaeological materials from a broader regional perspective that could show variations in different subareas. He defined the cultural sequence of the local area as follows:

Atuel IV: This period is associated with the transition from the Pleistocene to the Holocene, with dates ranging from 11,500 to 9,500 years BP. Sites attributed to this period contain evidence of cutting instruments and carbon associated with guanaco, Megatherium, Mylodontid and American horse (Lagiglia 1968, 1977a, 1977b, 1980, 1997). The period is further subdivided in three stages: Early, Middle, and Late preceramic. The first stage, described by Lagiglia (1977b) as Coroneles I, corresponds to non-specialized hunter-gatherers without projectile points characterized by flakes and scrapers. The second stage, described by Lagiglia as Coroneles II, presents thick flakes; it is also attributed to non-specialized hunter-gatherers (Lagiglia 1981). The third stage, described by Lagiglia as Coroneles III, corresponds to three traditions of specialized hunter-gatherers: 1) tradition of lanceolate projectile points between 10,000-8,500 years BP, 2) tradition of "apedunculadas andinas" projectile points

10,000-6,500 years BP, 3) tradition of triangular projectile points 10,000-4,000 years BP. These descriptions are not based in any absolute dating, all the speculations are based on surface materials of basalt (Lagiglia 1981).

Atuel III: This period is associated with hunter-gatherers that were "preparing terrain for agriculture" 4,000 years BP, corresponds to a culture with a development towards food production (Lagiglia 1997). According to Lagiglia (1981) these groups had a subsistence pattern of "sedentism with central base nomadism" that required seasonal transhumance. He further suggested that the change in technology, style, and subsistence resulted from the migration of populations from other regions.

Atuel II: This period is associated with experimented agriculturalists that arrived from 2,300-1,900 years BP. They based their economy on the cultivation of maize (*Zea mayz*), squash (*Cucurbita* sp.), beans (*Phaseolus vulgaris*), and quinoa (*Chenopodium quinoa*). They supplemented this agricultural diet by collecting chañar (*Geoffrea decorticans*), algarrobo (*Prosopis* sp.), *duraznillo* (*Ximena americana*), and hunting guanaco (*Lama guanicoe*), Rhea (*Rhea pennata*), and hare (*Dolichotis* sp.) (Lagiglia 1968, 1974, 1980). Lagiglia (1974, 1999) considered that southern Mendoza constituted the southern limit of early maize-based agriculture in the Central Western Argentina sub Area. At Gruta del Indio, for this period, there is evidence of ceramics, *coligüe* cane, cords, necklace beads, mollusk ornaments, and four burials. The recovery of a mummy, that belongs to a newborn child covered in leather carefully treated for its preservation, showed an intense care in the treatment of the deceased. These groups would have been composed by small nuclear or extended sedentary families that shared their settlements with hunter-gatherers, settling in the bottoms of the fertile valleys between the Piedmont and the eastern plains (Lagiglia 1999:253).

Atuel I: This period is associated with the arrival of the Spanish 500 years BP, and is based on rock art that illustrate Spaniards dressed in contemporary customs. Lagiglia (1977a) characterized this period as Neo-Araucanian culture. In addition, Lagiglia proposed a complex panorama for the groups living in southern Mendoza: some sedentary agriculturalists lived in the north of the Diamante and Atuel rivers and coexisted with nomadic hunter-gatherer groups further south (Lagiglia 1997).

In the 1990's, Víctor Durán, Adolfo Gil, and Gustavo Neme conducted dissertation research in the Grande River, the Payunia area, and the Highlands of the Atuel River, respectively. Durán (2000) elaborated an alternative chronological sequence and proposed the Grande River as an ethnic boundary between different hunter-gatherer groups. Gil (2006) worked in the Payunia area, where he focused on evidence for the occupation of marginal environments. Payunia is part of the Patagonian phytogeographic region, with more than 700 active and non-active volcanoes. Water exists in specific locations called *"jagueles",* which are accumulations of water generated after storms that can last 2 months on average. This makes the use of the landscape remarkably unpredictable. He also rejected the hypotheses that people at this time practiced agriculture in southern Mendoza, arguing that the little evidence for it is mostly associated with trade and symbolic contexts (Gil 2006). The results in the Highlands of the Atuel River, revealed occupations through the entire Holocene at altitudes not higher than 2,400 masl, and the presence of high-altitude villages above 3,000 masl only during the last 1,500 years BP (Neme 2007).

In summary, the four main regional dissertations on the archaeology of southern Mendoza involved descriptions of archaeological sites in the Atuel River (Lagiglia 1977a; Neme 2007), Payunia (Gil 2006) and the Rio Grande (Durán 2000). The topics discussed were: 1) the chronological sequences and changes in the subsistence systems across time, 2) early human occupations and coexistence with megafauna, 3) the middle Holocene hiatus of human occupation, 4) agricultural intensification in the last 2,000 years BP, 5) and occupation of marginal environments,6) ethnic associations related to ceramic distributions and trade of exotic objects across the Andes, and 7) paleo-environmental reconstruction. In the 15 years since this early research, at least 10 specialized dissertations have been produced on lithics, zooarchaeology (taphonomy, rodent remains, fish and bird remains), bio-archaeology (nutritional and labor stress), and archaeobotany (pollen, seed remains, and wood charcoal) (Andreoni 2014; Giardina 2010; Llano 2011; Otaola 2013; Salgán 2013; Corbat 2016; Fernández 2010).

3.2 **Previous works in the Diamante archaeology**

There are different descriptions of archaeological sites in the Diamante valley from naturalists and amateur explorers from the 1950s to the 2000s. The first mentions of archaeological remains, recovered without systematic studies, are from Sosa Morales (1979), who described the sites *el Medano de los Tolditos*, *Agua de los Cielos* and *La Cancha*, among others. Also, Rusconi (1962) mentions different kinds of sites: caves, rock art, and surface scatters. Their descriptions mention evidence of human remains, bones, lithics, and non-local (i.e. "exotic") ceramic styles. The first systematic excavations and descriptions, however, were conducted by archaeologists under the culture-history paradigm. Mariano Gambier excavated the sites Alero Puesto Carrazco, Alero Montiel and Carrizalito (Gambier 1979; 1985) (Figure 3.1). Lagiglia (1977a) describes the location called *Los Coroneles* which has evidence of chipped stone tools made from basalt. The chronology for this sequence is relative, based on comparisons of geomorphological descriptions and correlations. He characterized a society of hunter-gatherers that inhabited the area, calling them *Cultura de Los Coronele*s. He proposed three different chronological and evolutionary stages of production ranging from 10,000 to 5,000 years BP. *Coroneles I* was associated with large unifacial tools while *Coroneles III* has evidence of bifacial projectile points and scrapers smaller than in the previous stages.

Wood charcoal remains from El Mallín site revealed 9 local taxa; *Adesmia* and *Schinu* were the most abundant, both kinds of wood are highly valued as fuel in any context. Andreoni (2014) inferred the local provenance of wood according to the different taxa available in each phytogeographic provinces: Monte, Altoandina and Patagonia. The dates from the site allowed identification of two components related to the Early and Late Holocene. However, taxonomic diversity does not change significantly between both periods. Furthermore, the importance of the two main resources remained constant (Andreoni 2014). Wood charcoals remains from the El Indígeno site present 14 taxa; the main resources exploited are *Adesmia* and *Escallonia*, which are available locally. The sample has evidence of woods from both sides of the Andes and from lower altitudinal zones, which are more frequent in the last 1,000 years BP (Andreoni 2014). This suggest that there might have been an overexploitation of wood around the site, which was complemented with other firewood available 40-50 km away (Andreoni 2014).

Macro-botanical remains from El Mallín, Alero Montiel, and Carrizalito indicate that *Schinus* and *Prosopis* were consumed between 3,000-1,500 years BP, after which lower-ranked plants, including domesticates, were incorporated into the diet, indicating that diet breath expanded (Llano 2011; Llano et al. 2011). Supporting the trend of an expansion of diet breath, calculations for the return rate for *Schinus* is 3,100kcal/kg and for *Prosopis* is 3,600kcal/kg, which contrasts with the rest of the plants incorporated, including domesticates and other taxa from wild plants, *ca.*1,500 years BP, none of which exceed 2,000kcal/kg (Llano et al. 2011).

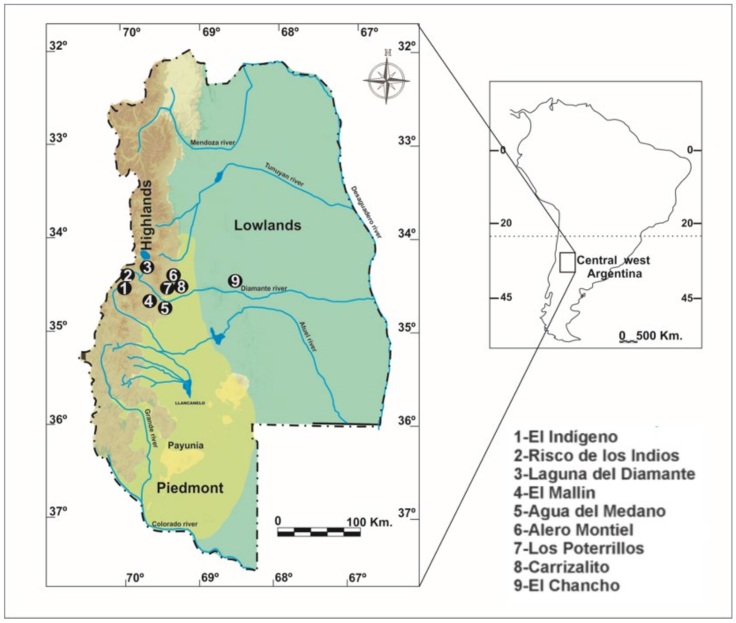

Figure 3.1 Archaeological sites and ecological zones in the Diamante valley: 1) El Indígeno; 2) Risco de los Indios; 3) Laguna del Dimante; 4) El Mallin; 5) Agua del Medano; 6) Alero Montiel; 7) Los Potrerillos; 8) Carrizalito; and 9) El Chancho.

During the last two decades, systematic excavations have been conducted at three high elevation sites with stone structures: El Indígeno, Laguna el Diamante, and Risco de los Indios (Figure 3.1). These sites date to the Late Holocene, all of them share certain characteristics: 1) they are located between 2,400 and 3,400 masl, next to water courses and patches rich in flora and faunal resources called "*vegas*"; 2) they are close to mountain passes and contain stone structures; 3) they were occupied within the last 2,000 years BP and had a focus on camelid hunting with complementary use of wild and domesticated plants; and finally 4), they all contain obsidian and ceramics from both sides of the Andes (Durán et al. 2006; Neme 2007; Morgan et al. 2017).

On the basis of more than 200 stone structures, El Indígeno has been described as a summer occupation linked to a pattern of a vertical transhumance. Further evidence includes goods from both sides of the Andes: ceramics, shells, domesticated plants (maize), high proportions of guanaco (*Lama guanicoe*) and birds (Neme 2007). The importance of ceramics at El Indígeno is evident from the results of an index showing the amount of ceramics divided by the sum of other archaeological materials, evidencing the highest ratio for the region (Neme 2007). In addition, some pots were found upside down and this was interpreted as a cache strategy for the re-occupation of the site (Lagiglia 1997). Neme (2016) argues that the structures were not occupied simultaneously; some of the newest structures were built with rocks from the older ones. Guanaco is the main resource consumed, supplemented with processed plants as suggested by remains of both maize and grinding stones. Some remains that belong to the Lowlands such as *Zea mays, Lagenaria sp., Empetrum sp.,* obsidian, silica, steatite, pottery, and mollusk shell, suggests both the intention to minimize risk at high altitude. The amount and diversity of goods from both sides of the Andes has been interpreted as the exchange between communities from Chile and Argentina (Neme 2016).

Durán et al. (2006) reports 60 structures grouped in 15 different archaeological sites around the Laguna del Diamante at 3,300 masl. Laguna del Diamante has the oldest radiocarbon date for a high-altitude village in the southern Andes: 2,100 years BP. Near to Laguna del Diamante are two sources of obsidian (Cortegoso et al. 2012). The results from excavations indicate 40-75% presence of obsidian, the presence of ceramics from both sides of the Andes, and high abundance of guanaco, Dasipodidae, rhea, and later caprines associated with the contact era.

Risco de los Indios consists of 29 structures mainly circular or ovoid. The archaeological record presents local plants, animals, and lithic raw materials; however, obsidian, ceramics and *Phaseolus* sp. come from the Lowlands or even as far away as Chile (Morgan et al. 2017). The main difference of Risco de los Indios to El Indígeno and Laguna del Diamante, is that it has fewer structures and it was occupied later. Morgan et al. (2017) suggest that the use of high elevation villages began about 2,100 years ago, peaked between 1,500 and 600 years ago, and shifted or declined to slightly lower altitudes thereafter.

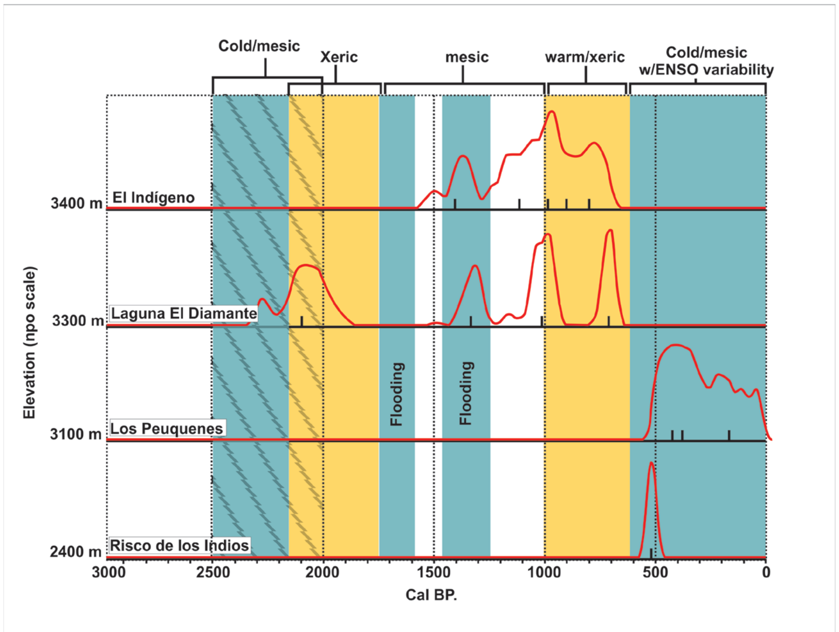

Figure 3.2 Comparison of paleoclimatic conditions with summed probability distribution of radiocarbon dates from four high-altitude villages located in southern Mendoza. ENSO = El Niño Southern Oscillation. Modified from Morgan et al. 2017.

Figure 3.2 shows the summed probability of high-altitude sites of the Diamante valley overlaid with a paleoenvironmental record synthetized in Morgan et al. 2017. The proxy records suggest differing information for the first occupations. Laguna del Diamante and El Indígeno were occupied in a period marked by both wet and dry-warm conditions. However, it is more conceivable that the colder and more variable environmental conditions of the Little Ice Age drove human occupations to lower elevation sites such as Risco de los Indios and Los Peuquenes, the last which is located in the Atuel valley (Cioccale 1999; Morgan et al. 2017). Neme (2016) explains that the occupation of El Indígeno is linked to an arid period, while Laguna del Diamante is linked to a wet period. Therefore, he disregards the occupation of these sites to be related to climatic conditions. Instead, the authors suggest that population packing and intensification of resource exploitation in the Lowlands on both sides of the Andes provoked a push to occupy locations above or around 3,000 masl *ca.* 2,000 years BP (Morgan et al. 2017).

3.3 **Ethnohistory**

The documents from the first century of European contact mention that to the north of the Diamante valley existed sedentary-agriculturalists called Huarpes, while in the south existed hunter-gatherer groups called Puelches (Canals Frau 1946). The Huarpes were subjugated by the Incas in the second half of the fifteenth century AD; there are chronicles that mention the Diamante river as the southern limit of the Inca empire (Bibar 1966; Bárcena 1998). However, the effective control seems not reach this far; instead it was confined to the Mendoza river valley. For the same period in the central Chilean territory, agriculturalists that spoke Mapuche were integrated with the Inca state. However, from the Maipo river valley to the south, there were hunter-gatherer groups and Mapuche free from the Inka influence (Cornejo and Sanhueza 2011).

3.3.1 **Sixteenth century**

The most informative historical chronicles about central western Argentina include descriptions made by Bibar (1966), written in 1558. His informants were Mapuches, who describe the populations from southern Mendoza as “Puelches”, meaning people from the East. Their subsistence system was described as being focused on hunting – which is at odds with an archaeological record that reveals the importance of plants as well (Lagiglia1997; Llano 2011). There are also some mentions of trade in which the Puelches provided blankets and rhea feathers in exchange for maize and other food. The descriptions of technology are limited to simplistic mentions of tents and a more detailed reference to clothing. They used some blankets pieced together from pelts. An important highlight, which is also absent from the archaeological record, is the use of a “tocado”, a headdress made of sticks and thread with a network of chords, that might have weighed between 5 and 10 kilos. The “tocado” functioned as a quiver in which they kept their arrows. The Puelches followed routes across valleys with high mobility. Their social organization was characterized by “parcialidades,” or “family bands,” of 20-30 people. Rather than promoting competitive behavior, these affiliation networks may have enabled people to exchange information about regional environmental conditions. The chronicles mention briefly the conflict between these groups over access to exotic goods. Finally, they describe the ritual sacrifice of animals on sacred rocks, probably associated with rock art locations. In terms of identity and language, it might be more prudent to consider the Puelches as a group that spoke a variation of Millcayac, which is also associated with the Huarpes from northern Mendoza. But they had a similar subsistence system to the Septentrional Tehuelches from Patagonia (Durán 2000).

3.3.2 **Seventeenth century**

Durán (2000) synthetizes the information for this period, which comes mainly from an *expediente*, or a colonial report, written in 1658 related to a frustrated incursion on the South Frontier by a *confederación* of Puelches and Pehuenches. The first relevant trait is the description of different *parcialidades* in southern Mendoza. Author interpretations differ, mainly because the informants were prisoners who may have concealed the geographic location of these groups. A conservative approach allows us to identify four *parcialidades:* Morcollames, Oscollames, Chiquillames and Oicos. However, the information about social organization is mixed, so these identity ascriptions only serve to signal the internal social variability of the people of southern Mendoza. The Chiquillames may have been occupied the Diamante River, while also occupying a portion of the Atuel River and the Nevado volcano. In the subsistence descriptions, there is a clear interaction between the Puelches and Pehuenches from the south. The horse takes on importance as the main domesticated animal followed by the dog, both of which were used in hunting, and not only for travel or transport but also for food. In addition to the hunt of guanacos, hares, rheas, deer, armadillos and vizcachas there are mentions of the use of algarrobo (*Prosopis flexuosa*), and molle (*Schinus polygamous*). Also, the use of *charqui* (guanaco dry meat) was a frequent way to conserve and defer meat consumption. The trade networks mention that the Puelches acquired arrows from the Pehuenches, both obsidian points or colihue (*Chusquea culeou*) cane. Trade also involved European goods such as horses, dogs, and feathers that were supplied by the Puelches to the Pehuenches, who in turn supplied arrows, textiles, swords, and spears from the Europeans. The Pehuenches had a more marked role as traders and warriors who led more violent incursions against the Spanish colonization; however, it was common for them to join with the Puelches in *malocas*, war incursions to the forts, in which they took captives. The alliances involved intergroup marriages. The clothing described for the seventeenth century is also made of pelts, textiles from other groups, and European fabric. It is mentioned that they used grease and pigments to cover their bodies. The bow they used is as tall as a man and the arrows are 90cm long. In addition to warfare items incorporated from the Spaniards, the chronicles also mention *boleadoras,* or weapons made by leather cords and stone balls. In terms of mobility there is a reference to 200km of travelling in one month, although we have to take into consideration the bellicose purpose of this movement which may have forced human groups to move longer distances.

3.3.3 **Eighteenth and nineteenth centuries**

Major changes occur during these centuries in the organization of the parcialidades mentioned before. Economically there is an increase in the trade of cattle with well stablished routes from the Argentinian pampas to Chile (Durán 2000). Other goods traded were salt, textiles, fusel oil, and gypsum. Due to the high demand for textiles from the Spaniards, these communities started an intense textile production, and the value of sheep increased owing to the demand for wool. Houses were made of horse hide and sticks, and the fire was always maintained inside. There are descriptions of local ceramics production as well as ceramic goods obtained through trade with Chile; their use was to store grease, seeds, and other foods. In sum, the Pehuenches and Puelches became horse herders occupying the region in the following way: the tolderías (group of houses made with sticks and leather) settle in the valleys with each domestic unit having a large space allowing for the rotation of grasses and for the location of three or four settlements either as summer or winter settlements; the use of horses allowed for pasturing in the valley far away from the tolderías; between April and September they were in the winter settlements, while between October and March they settled in the highest locations of the territory. The location of the tolderías was mainly in places that provided protection within the valley in which they controlled trade routes and strategic points.

3.3.4 **The Puesteros**

Nowadays, the Puesteros occupy the rural area of southern Mendoza. They are shepherds who take care of goats, cows, horses, and sheep in order of importance. Although some maintain steady year-round settlements, most of them have a seasonal round divided into two movements:

The *invernada* occurs during winter when they settle in the Lowlands, the whole family group coexisting in the household; the *veranada* occurs in the summer when the shepherds, usually men, take the cattle to the Highlands so that the grasses in the Lowlands can recover. Agüero Blanch (1971) described ceramics produced by women in the puestos (houses, usually next to a corral, a water stream and trees) in the early twentieth century, but that practice was abandoned. These communities have marked gender-based tasks. The men manage the cattle and hunt wild animals to complement the diet. Women take care of the domestic activities, including the maintenance of chickens and orchards. Trade with urban centers is sporadic, taking place when the Puesteros make trips to the nearby cities or when merchants visit the puestos. Unfortunately, there have been extremely few systematic ethnoarchaeological studies done on Puesteros. Otaola et al. (2016) examined the distribution of faunal remains surrounding the puestos from a zooarchaeological and taphonomic perspective. They identified differences in the patterns of consumption of wild and domestic animals as well as of meat acquired from the urban centers depending on the degree of sedentism of the puesto and its proximity to the modern-urban economy.

Miguel Giardina (pers com) was available to participate in a "boleada", a practice in which puesteros gather secretly to hunt rheas. This is an extremely difficult practice to witness, because the hunt of rhea is forbidden by the provincial government though Puesteros can hunt a fix number of wild animals per year. In consequence, the Puesteros are extremely cautious when organizing a boleada. Giardina argues that the hunt of rhea is a social event in which showing off and games among men are more important than the nutritional value of rhea meat. The boleada must always engage more than 10 men by horse, who try to capture the rhea by creating a circle and allowing different puesteros to ensnare the animal with a boleadora. After the capture, the rhea is often cooked in the "challa en bolsa" fashion, which entails putting all the bones and meat of the animal in a bag made of its own skin. This meal is quite greasy and often is not enough to feed all the hunters. Giardina spent three days with 15-20 Puesteros chasing rheas, but only captured two specimens. The event produces a high degree of comradery among the group of hunters, and many jokes and comments that last months and years about who missed a shot and who was successful. The importance of this observation leads us to consider that it is almost impossible to hunt rhea without the horse, which was only introduced to the region in the sixteenth century. Yet the rhea are valuable to hunter-gatherers because of the dietary value of their eggs, which are only available in the spring.

3.4 **Update on current archaeological data for southern Mendoza and the Diamante valley**

I consider two lines of evidence as the most developed in the archaeology of southern Mendoza that are relevant for the research questions of this dissertation: 1) Trends in 14C dates; and 2) zooarchaeology. Here I synthetize the topics and results of each.

3.4.1 **^{14}C dates**

Radiocarbon dating as a demographic proxy permits identification of the following trends across the Holocene: 1) The timing of the first occupations (Neme and Gil 2008a); 2) a hiatus in the Middle Holocene, often called “silencio arqueológico” (Neme and Gil 2008a); 3) the impact of the Little Ice Age; 4) the incorporation of maize; and 5) the impact of the Inka contact prior to the arrival of the Spanish (Gil et al. 2014).

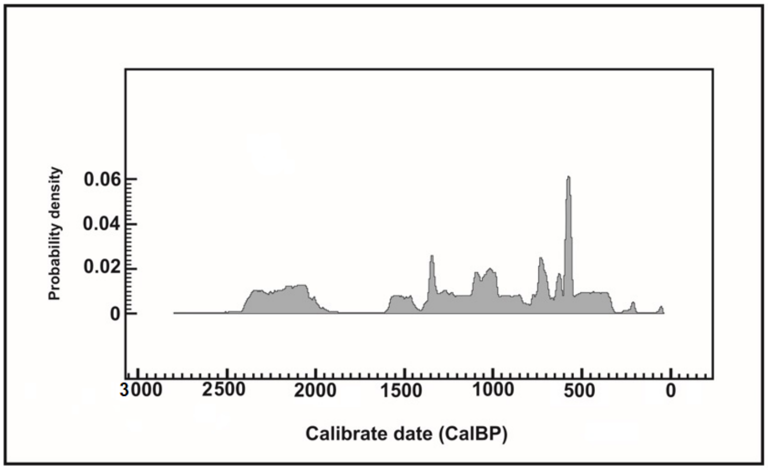

Figure 3.3 Summed probability distributions obtained from dates associated to cultivated plants. Modified from Gil et al. (2014).

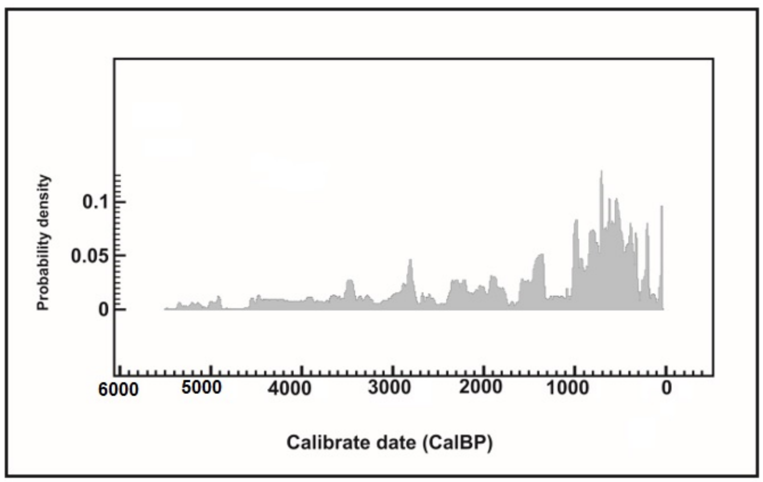

Figure 3.4 Summed probability distributions obtained on dates from southern Mendoza. Modified from Gil et al. (2014).

Gil et al. (2014) explore the relationship between demography (using radiocarbon dates as proxies) with the incorporation and further use of cultivated plants (also using radiocarbon dates associated to evidence of domesticated plants). The figures report the dates in radiocarbon calibrated years BP as they were published in Gil et al. (2014) (Figures 3.3, 3.4). However, in the text I follow the discussion in uncalibrated years BP as the original text from Gil et al. (2014) does not discuss the patterns observed using radiocarbon calibrated years BP. The authors report a complete data set with radiocarbon dates known at the moment for southern Mendoza (Gil et al. 2014:531-538). In Figure 3.3, the summed probability distributions for dates obtained for cultivated plants in the Cuyo area, which encompasses Mendoza and San Juan Provinces, indicates a first group of evidence marking the appearance of cultivated plants at around 2,400 years BP and lasting until 2,000 years BP; and a second group that lasted from 1,600- 200 years BP. This second group has a significant diminished density between 300-150 years BP, and a conspicuous peak between 600-550 years BP (Gil et al. 2014). In addition, ^{13}C isotope analysis on human bone coincides with these temporal patterns. Despite the increase of C_4 consumption associated with maize, the authors warn about the high regional variability on the role of this cultigens in human diet (Gil et al. 2006; Neme et al. 2015). In Figure 3.4 we observe the summed probability distributions of radiocarbon dates for southern Mendoza (Gil et al. 2014), showing some peaks of date densities in three different moments of the Late Holocene: 1,400 years BP; 1,000 years BP; and between 700-500 years BP.

Figure 3.5 shows the dates available from each ecological zone in the Diamante valley. In the Highlands, dates from El Indígeno, Laguna del Diamante, and Risco de los Indios indicate human occupation during the Late Holocene. In the Piedmont, dates from El Carrizalito, Los Potrerillos, El Mallín, and Alero Montiel indicate human occupation during the Early and Late Holocene, with a hiatus of occupations between 8,200 and 3,600 years BP. In the Lowlands, dates from human remains found in Los Reyunos and El Tigre belong to the Late Holocene, while dates from the site El Chancho belong to the Final Pleistocene-Early Holocene as well as the Late Holocene. Figure 3.5 confirms that the temporal trends accord to the expectations generated by Neme and Gil (2008a) in the biogeographical model proposed for southern Mendoza. In the Early Holocene, the Lowlands and the Piedmont show evidence of human occupation. In the Middle

Holocene there is a gap in the archaeological record also observed in the adjacent valleys (Garvey 2012; Gil et al. 2005; Neme and Gil 2009). In the Late Holocene, all the ecological zones are occupied.

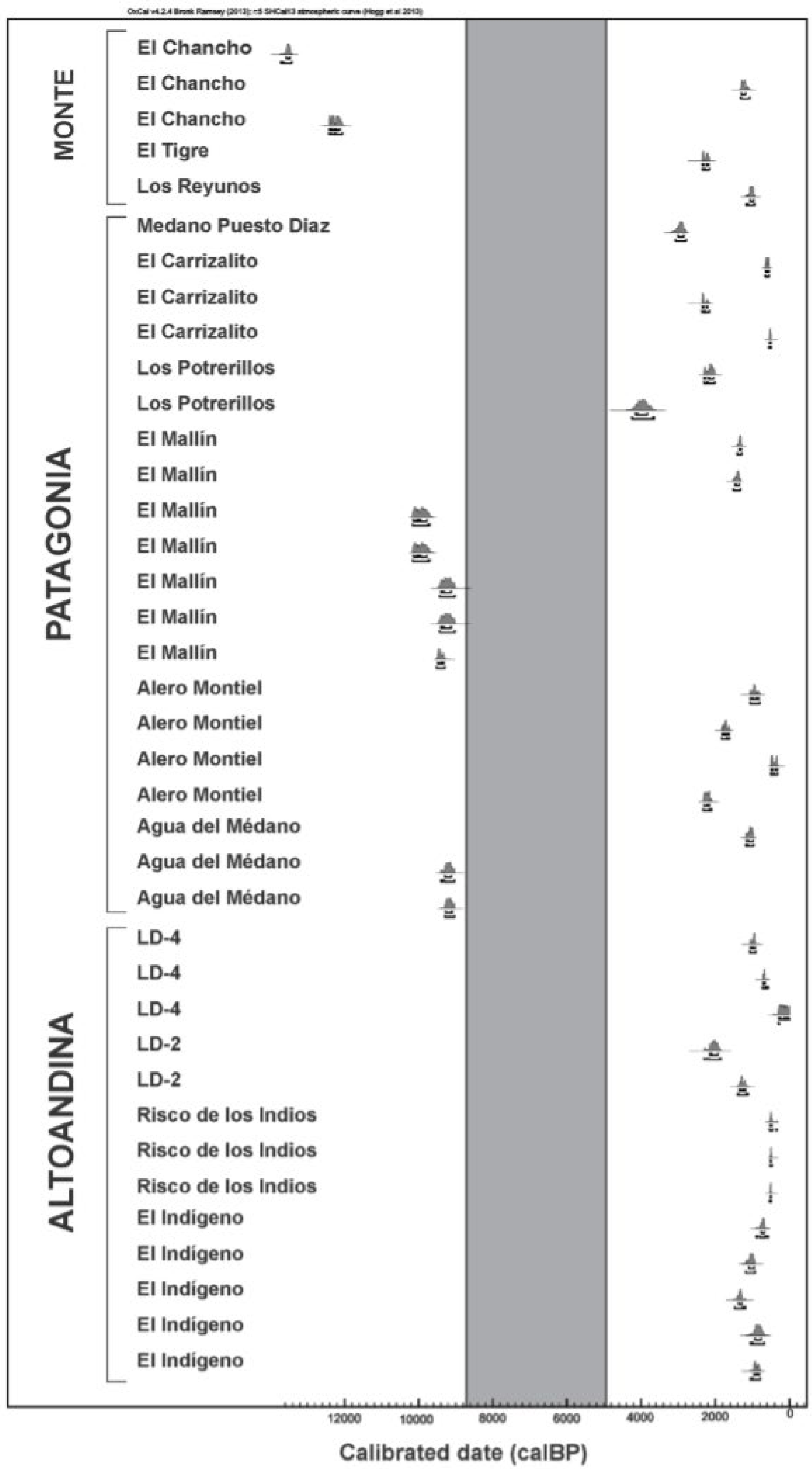

Figure 3.5 Calibrated radiocarbon dates. Grey area shows the chronological gap during the Middle Holocene. Radiocarbon data provided by Durán et al. 2006 (LD-4 and LD-2); Gil et al. 2009 (El Tigre, Médano Puesto Díaz, Los Reyunos); Llano et al. 2011 (Alero Montiel, El Carrizalito, Los Potrerillos), Neme 2007 (El indígeno); Morgan et al. 2017 (Risco de los Indios); Tripaldi et al. 2010 (El Chancho).

3.4.2 The zooarchaeological record of southern Mendoza

Zooarchaeology is perhaps the most developed of all forms of archaeological research conducted to date in southern Mendoza (Otaola et al. 2015). The research questions address the peopling of the region, mobility, and taphonomy, highlighting a biogeopraphic approach suggested by Neme and Gil (2008a) in which the use of space is strictly linked to the characteristics of different deserts: the Highlands, the Lowlands and the Piedmont. Based on the fauna available in each ecological zone, they suggest that site types will be highly diverse in the Piedmont due to its ecotonal characteristics, whereas site types will exhibit low diversity in the Highlands, while the diversity of site types in the Lowlands will be intermediate. In addition, Neme (2007) proposes an intensification process, in which more energy and time was needed to extract the resources from the most used ecological zones. He argues that this process was probably related to an increment in demography and diminished hunt of guanacos, the main resource in the area. This process also involved the appearance of new technologies related to a more "integrated" use of resources, the occupation and exploitation of marginal areas, utilization of new varieties of plants, regionalization of decorative styles, circulation of goods at a larger scale, increase in the dependency on storable resources, diminished mobility, and expansion of exchange networks (Neme 2007, 2009).

Otaola et al. (2015) present the results of 28 archaeological sites in southern Mendoza from the Highlands, the Piedmont, the Lowlands, and Payunia. Their results indicate the following general trends: 1) Fishes were mainly exploited in the Lowlands and Payunia, but limited to the Llancanelo Lagoon (Corbat et al. 2017); 2) two fish taxa were exploited: *Percichthys trucha* (perca criolla) and *Odontesthes hatcheri* (pejerrey patagónico) (Corbat et al. 2017); 3) these resources were present in the Late Holocene and associated with ceramics and lithics; 4) in the Highlands 22 bird taxa were found, 6 of them presenting evidence of human consumption, with the Piedmont having 14 taxa and only 4 of them showing human consumption, and the Lowlands and Payunia having 7 taxa, 3 of them showing human consumption; 5) small birds show evidence of being brought to the sites by natural predators, while medium and large birds show clear evidence of human consumption; 6) the consumption of large birds occurred in the last 3,000 years; 7) there is a negative correlation between the presence of rhea bones and the presence of rhea eggs in the archaeological sites, which could indicate a change in the access to nests in different ecological zones, or different costs in the exploitation of rhea or their eggs. In addition, the presence of this resource is associated with this preys' distribution; for example, in the Highlands the rhea is absent because their habitat does not exceed 1,600 masl. The presence of eggs in the Highlands sites indicates their conservation and transport from lower ecological zones; 8) only one taxon in the group of micromammals and reptiles presents evidence of human consumption though 17 taxa from this group appeared in the Highlands, 13 in Payunia, 11 in the Piedmont, and 8 in the Lowlands; 9) only two taxa, armadillos and guanacos, were consumed by humans in all the ecological zones, with 9 taxa in the Piedmont, 6 in the Highlands, 5 in the Lowlands, and 3 in Payunia. *Dolichotis patagonun* in the Lowlands, *Lagidium viscacia* in the Highlands and *Ozotocerus bezoarticus* in the Piedmont indicated human consumption.

Otaola et al. (2015) suggest that evidence for the process of intensification is not conclusive in all times or places. Instead, there are different patterns of fauna consumption according to the availability of resources in each ecological zone. There is more diversity of exploited taxa in the Highlands, followed by the Piedmont, the Lowlands and Payunia. Therefore, the authors conclude that the exploitation of animals does not reveal a process intensification by itself and needs other lines of evidence. While at the scale of the Highlands there are more taxa exploited, this is not the case for the other regions. Micrommamals do not demonstrate intense human consumption. However, for the Late Holocene, more bird species were consumed in the Highlands while more fishes were consumed in the Lowlands (Giardina 2010; Fernández 2010).

Neme and Gil (2008b) demonstrated that in the last 4,000 years BP the Index of Taxonomic Diversity and the Artiodactyl Index for 15 archaeological sites of southern Mendoza correlated. It is possible to determine how frequently low-ranking resources were incorporated to the diet, by calculating a diversity index with the analysis of assemblages from different points in time. The authors used the Shannon Index because it is more sensitive to differences among similar samples (Lyman 2008). They only incorporated species that indicated human consumption (Neme and Gil 2008b). The formula used implies the sum of the proportion of individuals from a species in relation to the total number of individuals (the relative abundance of a species) for each assemblage, considering also the total number of species (Neme and Gil 2008b). Therefore, the Shannon Index considers the number of taxa present in each assemblage and the relative contribution of each taxa to the assemblage. The results indicated that towards 2,000 years BP there were more taxa incorporated in the diet (Neme and Gil 2008b). In addition, the authors calculated the Artiodactyl Index which divides the total amount of Artiodactyl specimens by the total amount of specimens in the sample. The result is expressed in values from 0 to 1, when it is closer to 1, the importance of Artiodactyl in the sample is higher. For the samples in southern Mendoza, the importance of Artiodactyl diminishes towards 2,000 BP (Neme and Gil 2008b).

This implies that when more taxa are incorporated to the diet, there is a reduction in the relative importance of guanaco, which might otherwise be considered the main resource in the region. Following the logic of the diet breadth or prey choice model (MacArthur and Pianka 1966) this pattern suggests that human consumption of a broader range of resources (including low-ranked resources) is a result of a decline in the abundance of the highest-ranked resources relative to human demand. The authors argue that this was part of the intensification process in the region in the context of some sporadic use of domesticated plants and the occupation of ecological zones with diminished low productivity (Figures 3.6, 3.7).

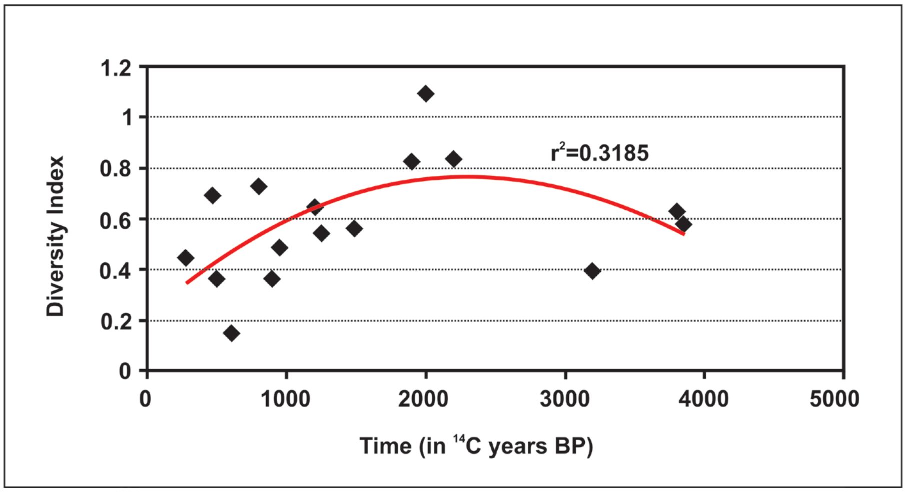

Figure 3.6 Faunal Diversity Index (y axis) through time (x axis). Each square represents zooarchaeological assemblages. The curve shows that around 2,000 years BP the assemblages had a greater diversity. Modified from Neme and Gil 2008b.

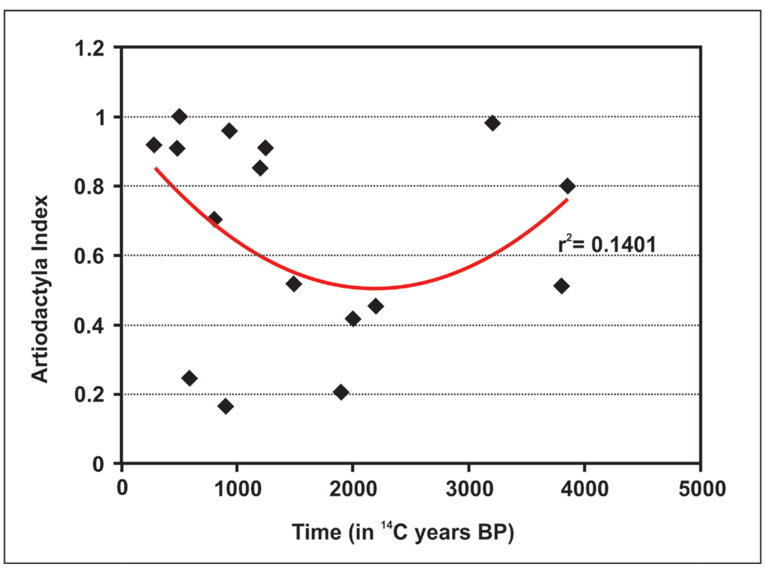

Figure 3.7 Artiodactyl Index through time from zooarchaeological assemblages from southern Mendoza. Each square represents a zooarchaeological assemblage. The curve shows a diminution in artiodactyla index around 2,000 years BP. Modified from Neme and Gil 2008b.

The fauna analysis from the Diamante valley shows that guanacos (Camelidae) were the dominant resource, present in all assemblages. In contrast to the observations of Neme and Gil (2008b) for the whole of southern Mendoza, Otaola et al. (2019) argue that in the Diamante valley there is no evidence of depression of the highest ranked prey; the guanaco. The Artiodactyl Index show high values; more than 0.6 in all the assemblages. Furthermore, all the assemblages across the Highlands and the Piedmont contain evidence of low ranked prey but in a very low proportion. However, the authors suggest that the diversity found across sites is due to the local availability of other species such as in the surroundings of lagoons or springs where different kinds of birds and small animals are accessible (Otaola et al. 2019).

In summary, the ethnohistoric background indicates major shifts in the centuries after the Spanish arrival in which the expansion of Mapuches generates a syncretism with the local communities. It is noticeable how the archaeology of southern Mendoza has been developing a consistent research agenda from a biogeographical perspective, in which the comparison of human adaptations to different deserts within the area is the core of the investigations. The radiocarbon dates and zooarchaeological remains indicates changes in the last 2,000 years BP, more taxa were incorporated to the diet and there is a trend to an increment of human occupations. The archaeological evidence from the Diamante valley has been mostly developed in the High-altitude villages which were occupied during the last 2,000 years BP. However, a group of other sites have generated radiocarbon dates that range all the span of the Holocene.

4.0 Methodology

4.1 **Distributional studies in small-scale societies**

Thomas's (1972) work represents the foundation of distributional studies on hunter-gatherers. His research aimed to test the validity of the ethnographic model proposed by Steward (1938) for the Shoshone in the Reese river valley of Central Nevada. His methodological contributions included an emphasis on using a random sampling strategy within a survey area, the importance of negative findings to interpret settlement patterns, and the equal representation of different ecological zones within the survey area to compare their use in the subsistence system—all of which ensured that the data collected were pertinent to his research questions. Bettinger (1978) applied similar research questions regarding the applicability of Steward's (1938) ethnographic models to Owens valley, Eastern California. Both authors used 500 x 500-meter tracts that contained the same proportions of ecological zones as found within the survey area. While Thomas (1972) found 75% correlation between the expectations of the ethnographic model and the results from the archaeological record, Bettinger (1978) found only 22% of correlation for the same comparison, concluding that the ethnographic model for the Shoshone was not a good analog for the subsistence system of Owens valley. The use of similar methodologies in different valleys following the same research agenda, allowed Bettinger and Thomas to identify the diversity of human adaptative strategies within ecological zones in desert areas but also among different regions. The same logic remains valid today: systematic collection of data of a similar quality within and among deserts enables more accurate comparisons of the strategies humans used to adapt to marginal environments and manage risk. Many other contributions followed his distributional approach to the study of small-scale societies with subsequent discussion focused on differences in survey areas, units of analysis (e.g. the site, the artifact, densities of materials per area), settlement patterns, dispersion and clustering of the surface record, and statistical methods among other topics (Ebert 1992, Crumley 1979, Ammerman 1981, Lovis 1976, Dunnell and Dancey 1983, Wobst 1976).

To date, the distributional archaeology of Patagonia has relied almost exclusively on the use of line transects. Belardi (2005) set the standard for distributional studies in Patagonia by comparing different environments: coast and low steppe, low steppe, high steppe, and forest. His core objective was to assess the different relevance of such environments to the subsistence system, and to address how mobility strategies were used by hunter-gatherers to mitigate risk and adapt to various conditions across the Holocene. In Belardi's methodology highlights the use of linear transects and the distance among the survey areas representing each environment, which were not contiguous.

Gil and Neme (2006) report the most clear and detailed distributional study done in southern Mendoza in the last 20 years. The authors compare three areas, two of them located in Payunia and the other one in Laguna Llancanelo, with the objective of identifying the archaeological character of each environment. They use a distributional approach in which they consider the artifact as the unit of analysis. In Llancanelo they cover 40 lineal kilometers, in 18 transects, resulting in 386,800 m^2 surveyed and a density of 0.002 artifact/m^2. In ALPA, a sector of Payunia, they covered 48 lineal kilometers, resulting in a 193,440 m^2 surveyed area and a density of 0.005 artefact/m^2. They do not report the number of transects in the text, but in tables 3-4 they refer to 7 transects. In ALPA-ESTE, an eastern sector of Payunia, they covered 44 lineal kilometers, resulting in 177,600 m^2 surveyed and a density of 0.0005 artifact/m^2. They do not report the number of transects in the text, but in tables 5 and 7 they refer to 7 transects. Gil and Neme (2006) conclude that the archaeological record of Llancanelo has a different pattern of human occupation when compared to the two areas of Payunia, mostly owing to the absence of ubiquitous raw material sources and more water.

While this study was pioneering in setting up systematic transects to explore the distribution of artifacts in different landscapes, this approach has the following disadvantages: 1) there is often disparity in the length of the transects; 2) the transects are not randomly distributed, since they belong to CRM studies or transects organized around objectives of local interest; 3) the units within the transects do not have the same width, sometimes having 60 meters, other times having 100 meters, which makes comparisons among transects tricky; 4) the distance among the crew members and their number are inconstant as the lineal distance covered and the m^2 reported do not correspond among the three areas.

To test the validity of a supposed Middle Holocene hiatus in southern Mendoza, Raven Garvey designed a random survey sampling to test different environment types in the Middle Atuel river (Garvey 2012, Garvey and Bettinger 2018). Garvey selected 33 quadrats of 1 km^2 in an area of 140 x 20 km in the Atuel valley, with an altitudinal range from 2,500-1,300 masl. She established 6 transects of 1 x 20 km perpendicular to the Atuel river at 20 km intervals. Each transect was divided in quadrats and units were selected randomly. She added 5 more units to replace places that could not be surveyed due to access problems (Garvey 2012:254). Garvey also added 24 locations for "targeted inspection" to balance the samples in the environmental zones. She argues that the proposed design would allow her to cover "a wide range of riverine and non-riverine environmental zones at varying elevations" (Garvey 2012:251). This sampling design presents some disadvantages: 1) a small sample size (N=24) permits only low statistical confidence; and 2) the area covered is too large and presents different ecological zones that should have been targeted using a representative sampling according to their distribution.

4.2 **Survey design**

The objective of the methodology was to create maps that reveal the intensity of land use in the three ecological zones: the Highlands, the Piedmont, and the Lowlands (Figures 4.1, 4.2). To compare the intensity of the human use of space in the three ecological zones, I plan to establish different proportions of units occupied in each ecological zone. Also, I plan to assign error ranges no wider than ± 5% at a 95% confidence level to get a robust comparison of units occupied and not occupied for my conclusion. Then, the design followed a conservative approach as suggested by Drennan (2009: 139-143), to have a representative sample size for a systematic random sampling. This implies, conceptually, that the higher disparity possible between proportions of units with positive and negative findings would be 50-50%—half of the units of each ecological zone to be occupied, and half without indications of human occupations (Drennan 2009:142). When we assign an error range to a proportion of 50% we get the widest error ranges possible: ± 5% (Drennan 2009:142). This means, that if the proportion of units is narrower than half and half, we would get even narrower error ranges—which would be a very decent outcome (Drennan 2009:143). Then, for a confidence level of 95%, we would need a sample of 384 units (Drennan 2009:143). Again, this expectation allows a sample size that, with lower percentages of occupation, will produce even narrower error ranges.

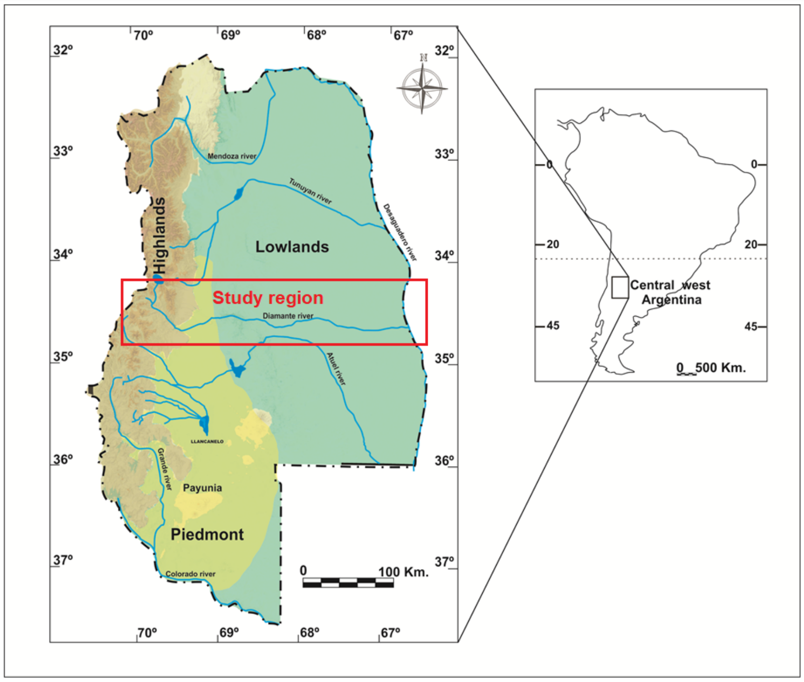

Figure 4.1 Map of Mendoza with the delimitation of the study region: the Diamante valley.

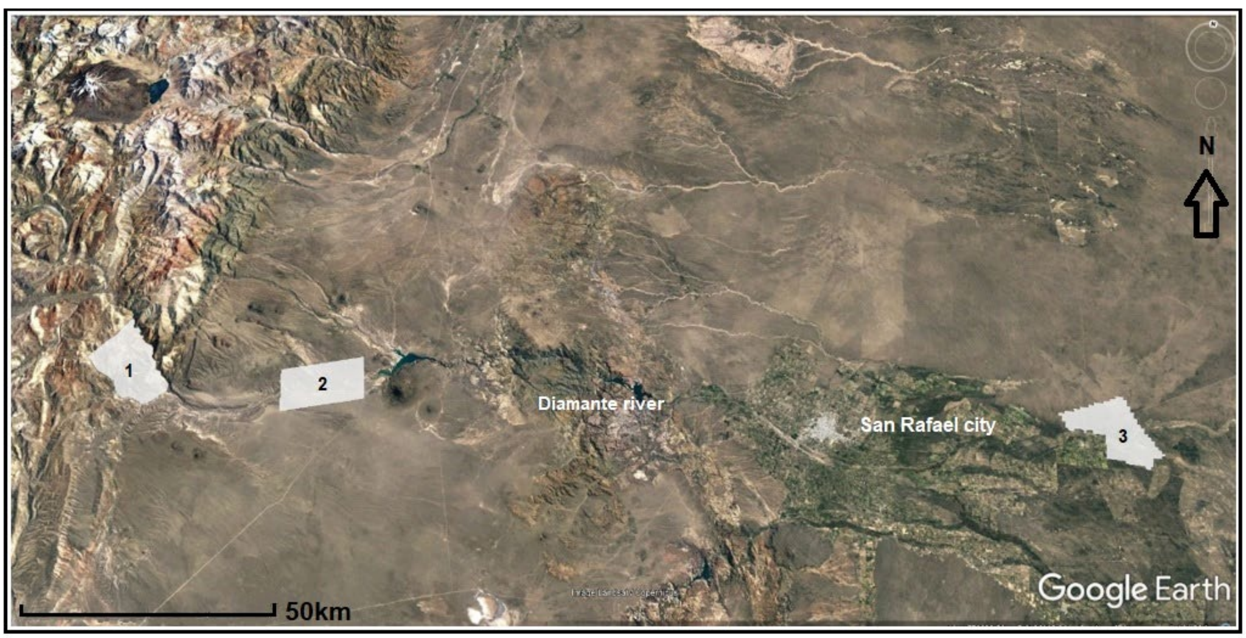

Figure 4.2 The three 100km2 areas selected in the Highlands (1), the Piedmont (2) and the Lowlands (3) in the Diamante valley.

One hectare units were selected from a group of 25 hectares in the three 100 km^2 areas (Figures 4.3-5). Due to the size of the cells and the irregularities of the boundaries of the areas, I selected 402 units for the Piedmont and 404 units for the Lowlands; and 400 units in the Highlands. However, 268 units were selected for survey using a slope filter of 20° (Figure 4.6). By slope filter I mean that every extension of land in the Highlands with slope values higher than 20° were excluded for survey. Every unit that felt on this extension of land was considered as units with negative findings as I considered that they were not suitable for human occupation.

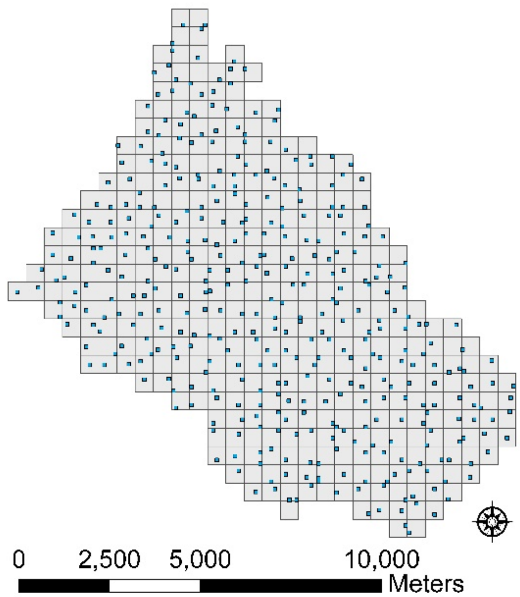

Figure 4.3 Grid of 25-hectare blocks (grey) in the Highlands, from which 400 units of one hectare were selected (blue – one randomly selected from each block of 25) in a systematic random sampling design.

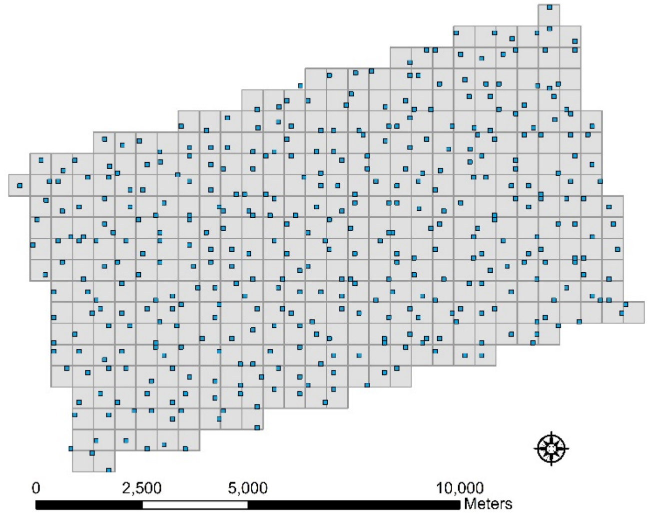

Figure 4.4 Grid of 25-hectare blocks (grey) in the Piedmont, from which 400 units of one hectare were selected (blue – one randomly selected from each block of 25) in a systematic random sampling design.

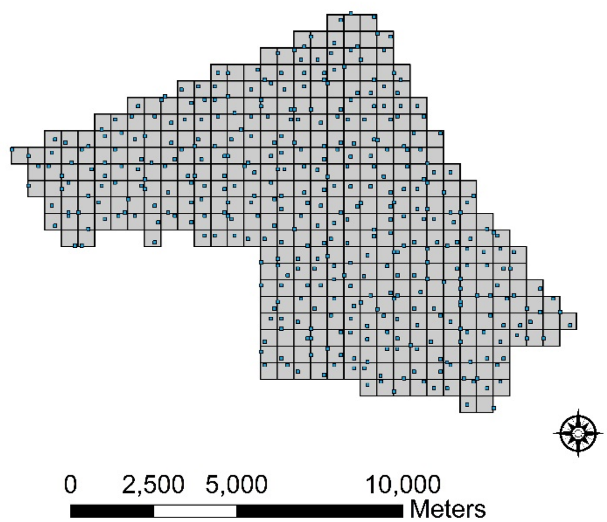

Figure 4.5 Grid of 25-hectare blocks (grey) in the Lowlands, from which 400 units of one hectare were selected (blue – one randomly selected from each block of 25) in a systematic random sampling design.

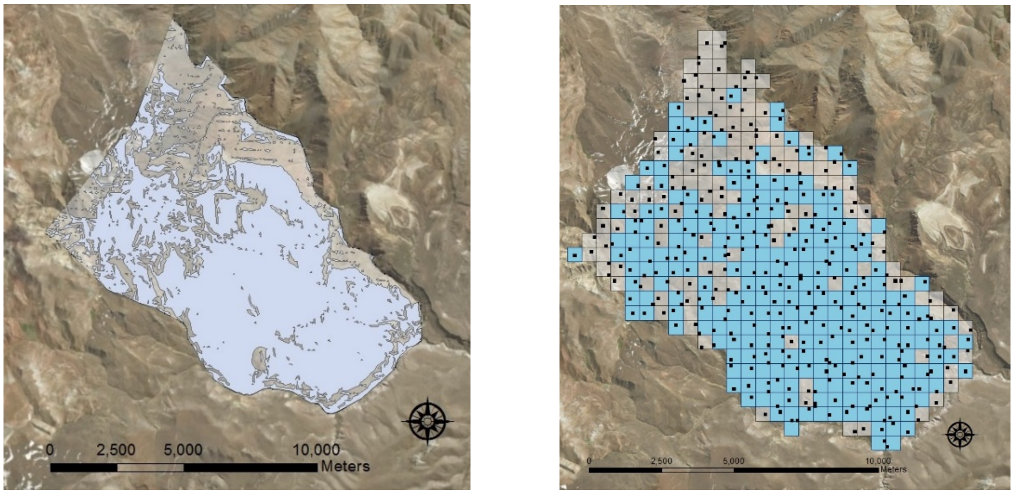

Figure 4.6 20° slope filter applied to units in the Highlands (left). Units that were selected for survey after the slope filter (right).

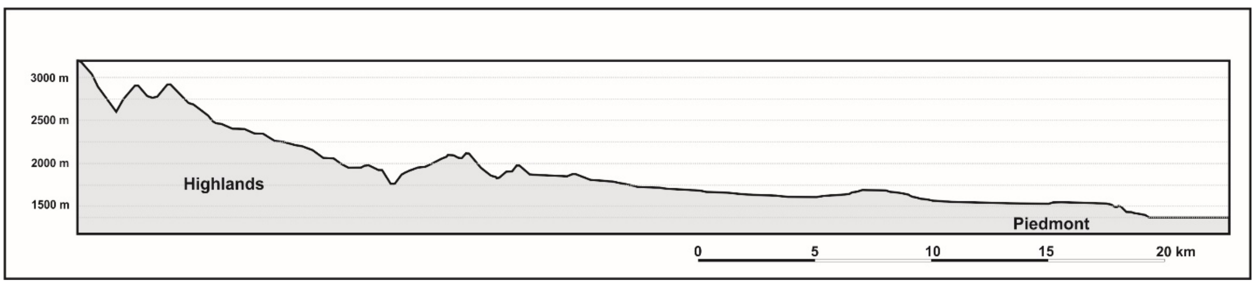

Figure 4.7 Slope profile from the Highlands and the Piedmont of the Diamante valley.

To examine each 1 ha survey unit, members worked in pairs and on foot. In the Highlands and the Piedmont, the procedure involved each pair getting to the initial vertices and walking in a direct line to another vertice, with crew members maintaining a 15-20 meter distance from one another (Figure 4.8). Then they walked to the middle of the unit, did the same procedure in the opposite direction, and finally crossed the unit for a third time from the third vertice to the fourth. This allowed them to cover each hectare with two crew members separated by 15-20 meters, a procedure that allowed us to identify scatters of materials not smaller than 25 meters in diameter. A total of about 600 linear meters of each unit were covered by the crew members, multiplied by

4 meters, which is the average radius of human visual recognition. This allowed us to translate the square meters surveyed per unit to 2400 square meters.

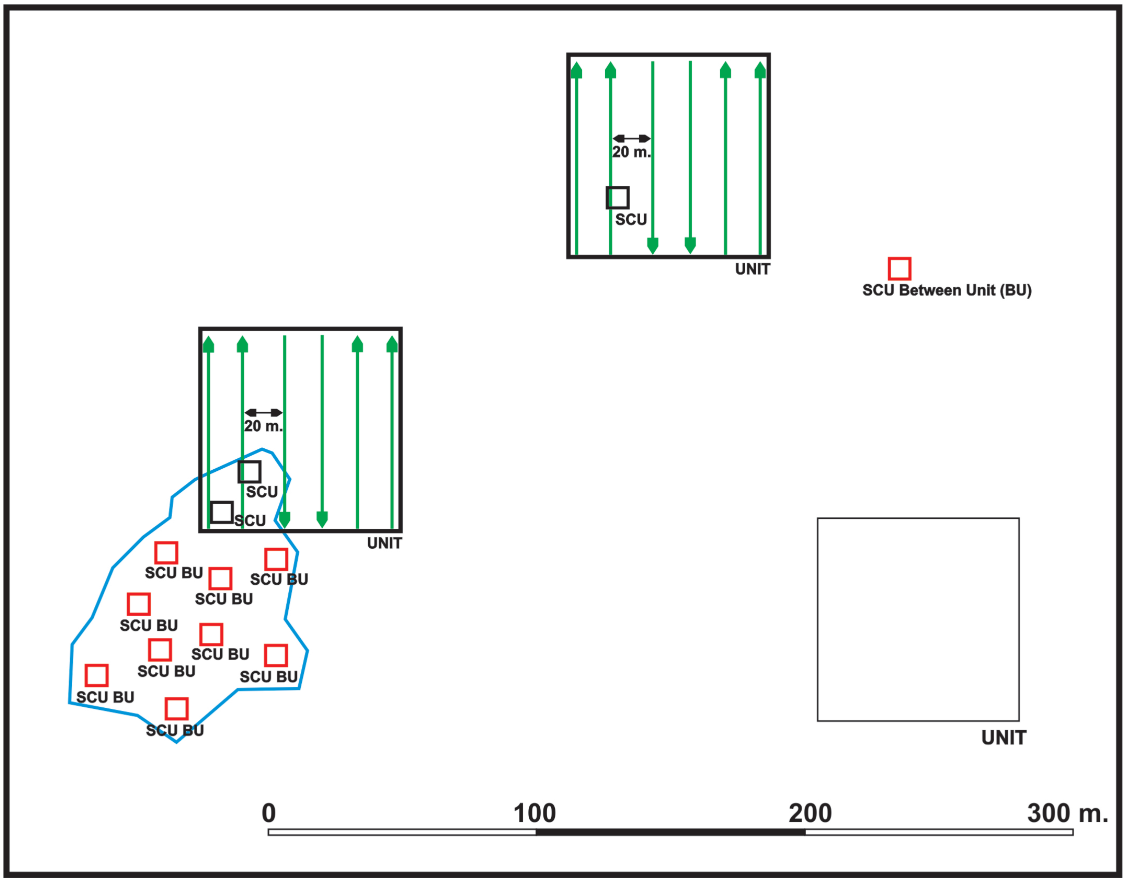

Figure 4.8 Graphic example of how the units and between-unit were surveyed in the Highlands and the Piedmont. In green are the lines representing the times that a crew member crosses the unit, separated by 20 meters. In blue is the area of a site. In red are Surface Collection Units between systematic survey units.

In the Lowlands, vegetation made this approach impossible, so we had to adapt it by doing a diagonal transect between two vertices of each unit. The crew members were many times separated from each other by 50 meters or more, trying to get through the vegetation. Frequently, the crew members could only pass in single file without the proper separation. Therefore, a realistic approach is that only 150 meters of these units were covered. Given this limitation, the proper percentage of visibility and real distance covered in each unit of the Lowlands have been calculated for comparison among the ecological zones.

When archaeological sites, scatters of materials or isolated findings appeared within units, we established Surface Collection Units (SCU). This involved assessing squares of 10 by 10 meters (100 m^2) and collecting all the archaeological materials within them. These SCUs were also collected between units. The number of archaeological materials in them range from 1 to more than 100.

This methodology improves on other kinds of systematic survey, like linear transects and square kilometers quadrats, in several ways. First the sample size: one hectare units permits a larger sample than choosing quadrats of 1 km^2. Second, the use of one hectare among a group of 25 hectares in a random systematic way helps to avoid autocorrelation biases in the maps generated. Simply put, autocorrelation implies that nearby measurements of one particular variable tend to be similar. Therefore, it is better to avoid close samples, which systematic sampling tends to minimize. Furthermore, systematic sampling allows us to avoid leaving large amounts of space unsampled, which is intuitively appealing (Drennan pers comm). This is due to the correlation of the values of different categories, such as elevation, rainfall and slope between cells, that are contiguous. It is worthwhile mentioning that the size of the cells affects this correlation, since smaller cells are more likely than larger cells to represent similar values. Also, this effect diminishes with distance: at some point, for example, after 100 kilometers two cells are not affected by the correlation problem. Third, the scale: allows a proper size for surveying different ecological zones in a valley and for adding the same blocks in other environments, if necessary, for future research. Logistically this scale was also manageable. Further, it provides intuitive but important input on the distribution and availability of resources. Fourth, GIS friendliness: by using quadrats, it is easier to use the data in spatial statistics. Fifth, the collection of materials in each site: squares of 10 by 10 meters (area=100 m^2) permits the establishment of site size in a comparable way, and also the assessment of density of materials per area among different archaeological locations.

My unit of analysis is density of materials per area. The findings are also grouped in the following categories: archaeological sites with more than 25 artifacts; samples of artifacts of 4-25 in number from a single site; and isolated findings with samples among one and four artifacts. Since archaeological materials were collected in two different ways – both between and within the 1 ha survey units – I treat the two kinds of information separately. The aim is to keep statistical rigor and at the same time to incorporate useful information regarding the use of the space in the different ecological zones, while testing the impact of the methodology proposed. All the materials were collected and registered with GPS.

The crew members recorded the slope and visibility as described in table 4.1. This also allows the comparison of results from each ecological zone based on the area visible for inspection.

Table 4.1 Categories of visibility and slope in surface surveys.

Variable	Category	Definition
Slope	Null	0 º
	Very soft	≈ 15
	Soft	≈ 30º
	Regular	≈ 50º
	Pronounced	≈ 70º
	Abrupt	90º
Visibility	Null	0%
	Bad	≈ 20%
	Regular	≈ 40%
	Good	≈ 60%
	Very Good	≈ 80%
	Optimal	100%

Based on the visibility categories described in Table 4.1, Table 4.2 reports the conditions for units in each ecological zone (Figures 4.9-11). Overall, the Highlands and the Piedmont had very good visibility conditions. The Lowlands had close to 50% of units with poor visibility. In Table 4.3 is the report of slope measured by crew members based on their observations in the field. Some units were impossible to examine because vegetation, slope, or water made them impossible to access; therefore, these units were considered as with negative findings.

Table 4.2 Frequency and percentages of visibility per ecological zone.

Visibility	Highlands		Piedmont		Lowlands	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Nule	0	0.0	0	0.0	12	3
Bad	9	3.3	3	0.7	168	41.5
Good	87	32.4	201	50	90	22.4
Regular	14	5.2	32	7.9	109	27
Very good	149	55.8	139	34.5	11	2.7
Optimal	0	0.0	0	0.0	1	0.2
Impossible	9	3.3	27	6.9	13	3.2
Total	268	100	402	100	404	100

Table 4.3 Frequency and percentages of slope per ecological zone.

Slope	Highlands		Piedmont		Lowlands	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Nule	5	1.9	125	31.0	304	75.3
Soft	105	39.1	177	44.0	86	21.3
Regular	50	18.7	31	7.8	1	0.2
Pronounced	48	18.0	13	3.2	0.0	0.0
Abrupt	51	19.0	37	9.2	0.0	0.0
Impossible	9	3.3	19	4.8	13	3.2
Total	268	100.0	402	100.0	404	100

Figure 4.9 Example of slope and visibility in the Lowlands.

Figure 4.10 Example of slope and visibility in the Piedmont.

Figure 4.11 Example of slope and visibility in the Highlands.

4.3 **Ceramic analysis**

Ceramic materials were cleaned and then subjected to low power microscopic analysis with a binocular Nikon SMZ stereomicroscope 800 with objective magnification of 1x and 10x eyepiece. Maximum temper size in mm and temper size (Fine, Medium, Large) were measured following Orton et al. (1993).

Ceramic sherds were also analyzed macroscopically measuring in mm width, length, and thickness, and weight in grams. Different categories were recorded for surface treatment (polished, burnished, smoothed), decoration (painted, incised) and firing (oxidized, oxidized incomplete, reduced) (Orton et al. 1993; Simms et al. 1997).

The observed stylistic categories are Overo, Marron Pulido, and other styles from the eastern Andes (Neme 2007). To explore the degree of investment in ceramics production, I will focus on 4 variables based on these expectations: finer wall thickness demands more work while the pot is more unstable during manufacture; finer temper size implies some extra work in preparation before its addition to the clay; reduced firing implies special techniques which implies more time and preparation; and smoothing is the most inexpensive surface treatment in terms of time and effort, as opposed to brushing and polishing (Orton et al. 1993). Table 4.2 presents the degree of investment expected for different states of the variables thickness, temper size, surface treatment, and firing.

Table 4.4 Degree of investment associated to different states of variables.

Degree of investment	Thickness	Temper Size	Surface Treatment	Firing
High Investment	5 mm	Fine (0-0.2mm)	Polishing	Reduced
Moderate Investment	6 mm	Medium (0.2-0.5mm)	Brushing	Oxidized incomplete
Low Investment	7 mm	Large (+0.5mm)	Smoothing	Oxidized

4.4 **Lithic analysis**

The analysis involved separating different artifact types: debitage, tools, and cores. All materials were measured in the variables width, length, thickness and weight. In addition, I noted color, along with thermal or post-depositional alteration. Examples of chipped-stone artifacts from both the Highlands and the Piedmont are illustrated in Figures 4.12 and 4.13. The percentage of cortex on each artifact was divided into three interval categories: 0%, 1-50%, 51-100%. The raw materials were divided into four categories: basalt, cryptocrystalline, obsidian, and other.

For the debitage analysis the categories for flake types were primary (51-100% of dorsal cortex), secondary (1-50% of dorsal cortex), angular, and core flake (usually with some portions of cortex), following Aschero and Hocsman (2004). A different level of preparation of the platform can indicate different levels of investment in tool manufacturing (Andrefsky 1998). Therefore, I recorded the categories cortical, flat, complex, and abraded for the striking platform. The "cortical" platform is usually present in the first stages of manufacture and can be associated with dorsal cortex on the flake. A "flat" platform is common in toolmaking and shows an average level of investment. Both "complex" and "abraded" platforms imply more energy spent in the tool making process (Andrefsky 1998). The logic behind platform preparation is to generate a surface from which a precision hit will have a highly more effective flake for further use as a tool (Andrefsky 1998). Complex platforms are usually common in the context of formal tools production, which require more effort and dedication, and also when raw materials are scarce to secure precision during percussion.

The identification and counting of flake scars can be time consuming and difficult. Moreover, different analysts will differ in their observations. Therefore, I follow the approach suggested by Andrefsky (1998) in which an ordinal scale is preferable to an interval scale or the actual number counted, even assuming inter-observer differences. Then, a 0 is equivalent to a dorsal face covered by cortex; 1 to only 1 flake removal, which is easy to identify; 2 for evidence of 2 dorsal flakes removals, independently if there is still cortex or not; and 3 to any flake with more than two dorsal flake removals.

Cores were distinguished in different categories: unidirectional, bidirectional and multidirectional Andrefsky (1998). The negative flake removal was recorded as well as if the cores were exhausted or not. Tools were distinguished in different categories: projectile points, scrapers, bimarginal tools (with 2 cutting edges) and preforms Andrefsky (1998).

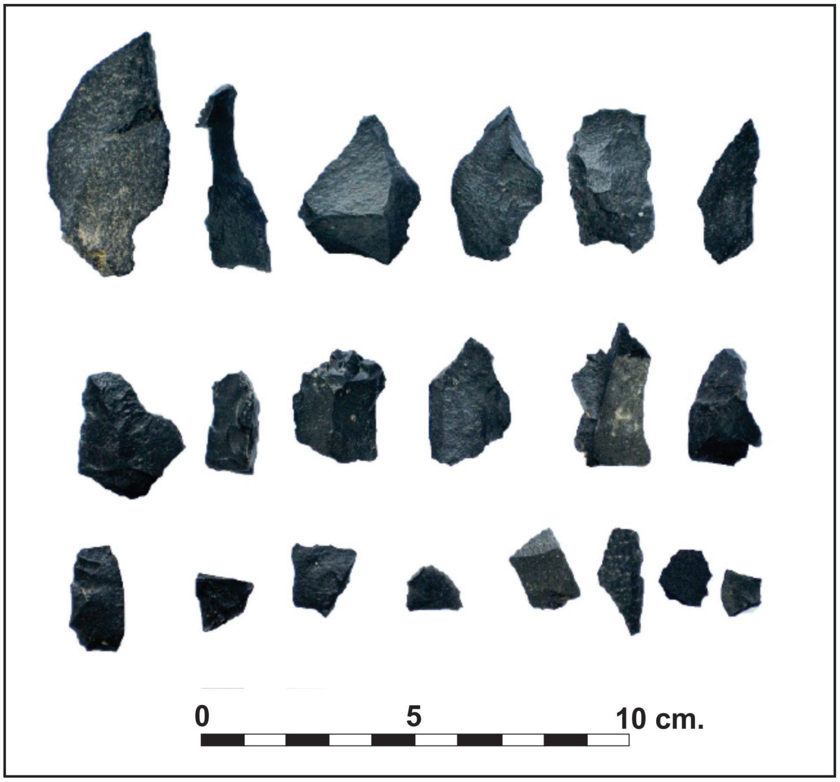

Figure 4.12 Lithics from unit 186 in the Highlands.

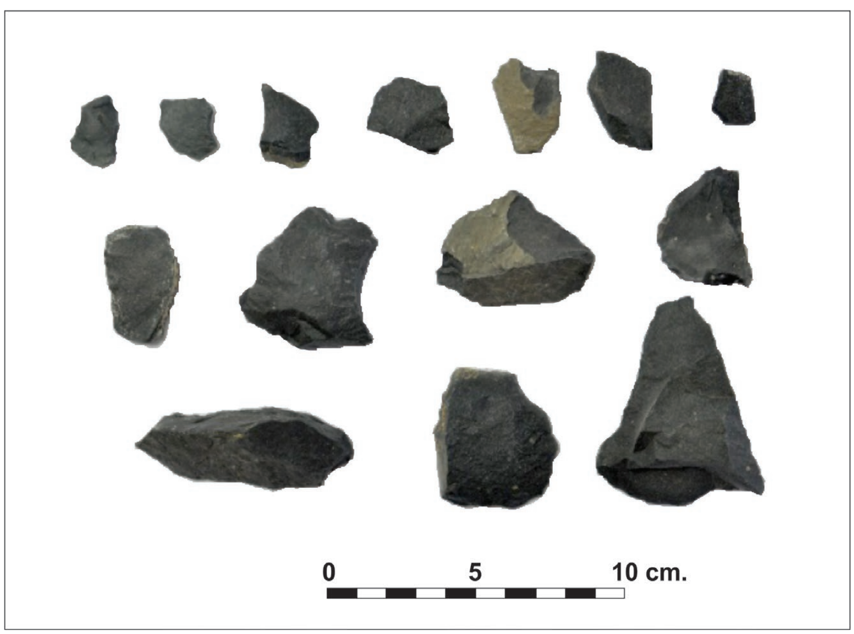

Figure 4.13 Lithics from unit 380 in the Piedmont.

4.5 **Statistics**

Bullet graphs for averages and proportions gives all the information that we need to compare assemblages at a given confidence level (Drennan 2009). The bullet graphs permit us to compare the end of the error range of a particular batch—a group of numbers, related to each other, which represent different states of the same entity"—to the estimated proportion or estimated mean of other batches. In Figure 4.14 there is an example which compares the weight in grams of lithic artifacts between the Highlands and the Piedmont. I added a red line from the estimated mean in the bullet graph from the Highlands so that the comparison could be easier. The distance between means are clearly separated. Therefore, we can assume with 80% (thicker bar), 95% (middle bar) and even 99% (thinner bar) confidence levels, that the samples came from lithic populations comprised of individual artifacts of different mean weights (in grams). In addition, bullet graphs tell us clearly and intuitively the role of sample size in our results, as we can notice that the error ranges increase with smaller sample sizes. A situation that can be solved assessing lower confidence levels (Drennan 2009).

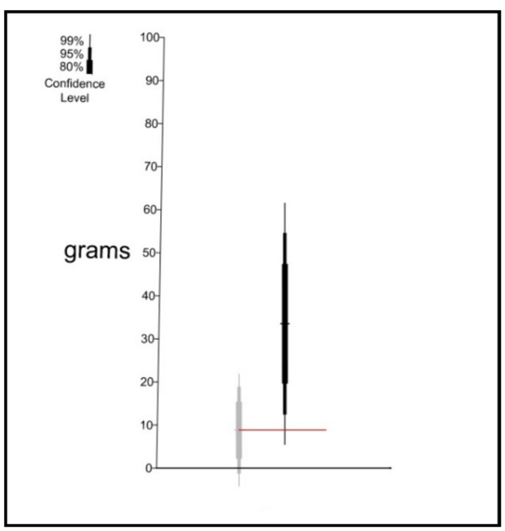

Figure 4.14 Weight in grams of individual lithic artifacts in the Highlands (grey) and the Piedmont (black).

In summary, this methodology attempts to recover in similar fashion data from all the ecological zones for proper comparisons of land use across the Diamante valley. The objective is to evaluate the intensity in land use according to the proportion of units with human occupations, the densities of human occupations and the characteristics of the organization of technology (e.g. lithics and ceramics). In addition, I plan to collect specific variables from ceramic sherds, such as temper size, thickness, firing and surface treatment to assign different degrees of investment to discuss how this technology was used. I will also inspect variables from lithics materials following broad categories such artifact types, raw materials types and percentages of cortex and how they these variables present variation across the landscape. For further detail, I will register different attributes within each artifact type that can be used as proxies of intensity in the use of raw materials such as types of cores, types of platforms in debitage, among others.

5.0 Results for ecological zones

5.1 **Land use in three ecological zones**

There are several population proxies for exploring demographic patterns and changes across time that archaeologists use. Among the most common ones are radiocarbon dates, counts of houses, counts of sites, densities of materials (counts of materials/m^2) and densities of materials per area (counts of materials/m^2 x area in hectares) (Drennan et al. 2015). From the previous list, the density of materials per area index can also be used to determine the intensity of land use (Drennan et al. 2015), which is among the main purposes of this dissertation. Therefore, by totaling the area-density indexes of the units in each ecological zone, I can compare which ecological zones were more intensively used. Furthermore, I plan to detect different uses of land from the perspective of the lithic organization. In this chapter I present density maps of the raw materials, types of artifacts and percentage of cortex in each ecological zone.

To demonstrate land use in the Diamante valley visually, I chose to present the data in surfaces that indicate, through variable elevation or peaks, the spatial distribution of archaeological materials. The best metaphor to exemplify how surfaces can be perceived is topography. In maps showing elevation, we can easily detect that places with similar values tend to be near each other. The phenomenon of having similar data values next to each other in space is called autocorrelation, which affects many variables across space: rainfall, slope, distribution of plants and animals, among many others (Drennan pers comm). Imagine that we have incomplete data on elevation or the distribution of archaeological materials in a given area, but we do have values that correspond to some points or hectares within a grid. This is exactly the type of data I collected in my survey design. Then, when we have missing data, we can assign a similar value to cells or pieces of land that surround the points or cells from which we have data. Thus, I used interpolation to generate new data within a range based on a set of known data and complete the values of cells with missing data. In this case, the interpolation relied on the data from 1-hectare units with positive findings, assuming that the values of land nearby, from which I had no information, would have similar values to adjacent sampling units with positive findings.

There are many interpolation methods, among which I used inverse distance weighting, which averages measured points, giving more weight to nearby measurements than to distant ones. Therefore, I normalized the information by interpolating the values of archaeological materials for each cell within the $100km^2$ area, so that the outcome is a complete set of values for every cell covering the area. What is more, inverse distance interpolation allows us to use different "powers" that can weight nearby measurements more heavily than distant ones, or vice versa. The higher the value of the power, the more abruptly contrastive are the surfaces generated. For example, a power of 0.1 tends to smooth out local anomalies and accentuate larger-scale trends more clearly. Inverse distance can therefore be used flexibly with different powers to demonstrate a variety of patterns at different scales. A power of 4 demonstrates very local landscape detail in a clean-cut way. Therefore, in my opinion, it is the power that most closely resembles where the data was obtained in the survey. In addition, it allows us a visual inspection of exactly where and how a particular variable (e.g. frequency of obsidian) presents variance across the landscape. In my opinion, the power of 4 works as a bridge to the observer between the results for a particular variable (e.g. frequency of basalts, frequency of tools, among others) and an average weighted surface (power of 0.1) that allows to perceive the use of land at the scale of the ecological zone for the same variables. So that the observer can interpret better, where were the specific locations that lead to an averaged image of the use of the ecological zone as whole.

Using surfaces always implies a series of subjective decisions. Yet we must be aware that the patterns observed are constrained by the data collected, and therefore do not comply just to our decisions about which method of interpolation to use. The options that I chose were driven by the intention to control focus in the maps that I wanted to develop—in this case a focus on the per-unit results and how variance in the distribution of archaeological materials is then averaged at the scale of ecological zone. In addition, to the area-density index and density map of lithics variables, I present information of specific variables, related to intensity of use, for debitage, cores and tools. Finally, I report the ceramics and milling stones found in the survey.

The Lowlands has 0.5% ± 0.5% of units occupied; the Piedmont has 25.25% ± 4.2% of units occupied, and the Highlands has 13.50% ± 3.3% of units occupied, at a 95% confidence level (Table 5.1; Figures 5.1, 5.2, 5.3, 5.4). Figure 5.5 illustrates the structure of the findings, in both the Piedmont and the Highlands; close to half of the units contain isolated findings, followed by units with scatters of 4-24 archaeological materials and then by those with concentrations of more than 25 archaeological materials in each of them. To calculate the area-density index I divided the counts of materials per the area in meters equivalent to SCU ($100m^2$) within each unit, with the area in hectares. These results are equivalent to simply divide the counts of materials by 10,000 m^2, which is the area in squared meters of the one hectare units. The sum of area-density index values per unit in the Highlands is 0.034 and in the Piedmont is 0.14, indicating high contrast in the intensity of land use (Tables 5.2 and 5.3).

Table 5.1 Frequencies and percentages of 1 hectare survey units with and without findings in per ecological zone.

Highlands		
Findings	Frequency	Percentage
Units without findings	346	86.5
Units with findings	54	13.5
Total	400	100

Piedmont		
Findings	Frequency	Percentage
Units without findings	301	74.7
Units with findings	101	25.2
Total	402	100

Lowlands		
Findings	Frequency	Percentage
Units without findings	402	99.5
Units with findings	2	0.5
Total	404	100

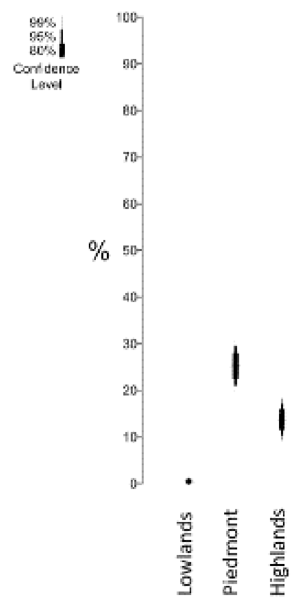

Figure 5.1 Bullet graph comparing percentages of 1 hectare survey units with human occupation in each ecological zone.

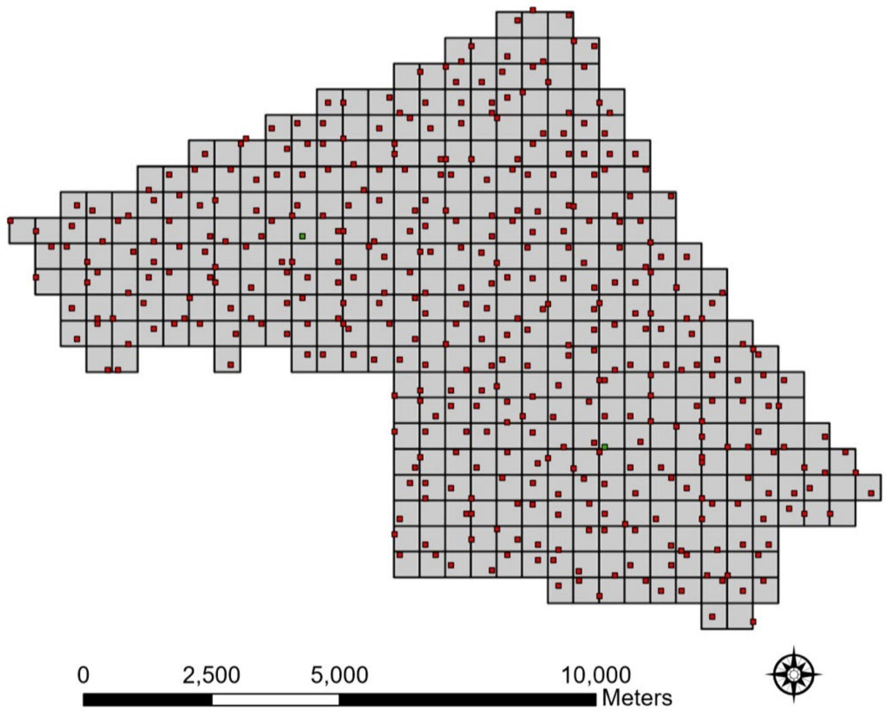

Figure 5.2 Map of the Lowlands with 1 hectare survey units showing presence (green) and absence (red) of archaeological materials.

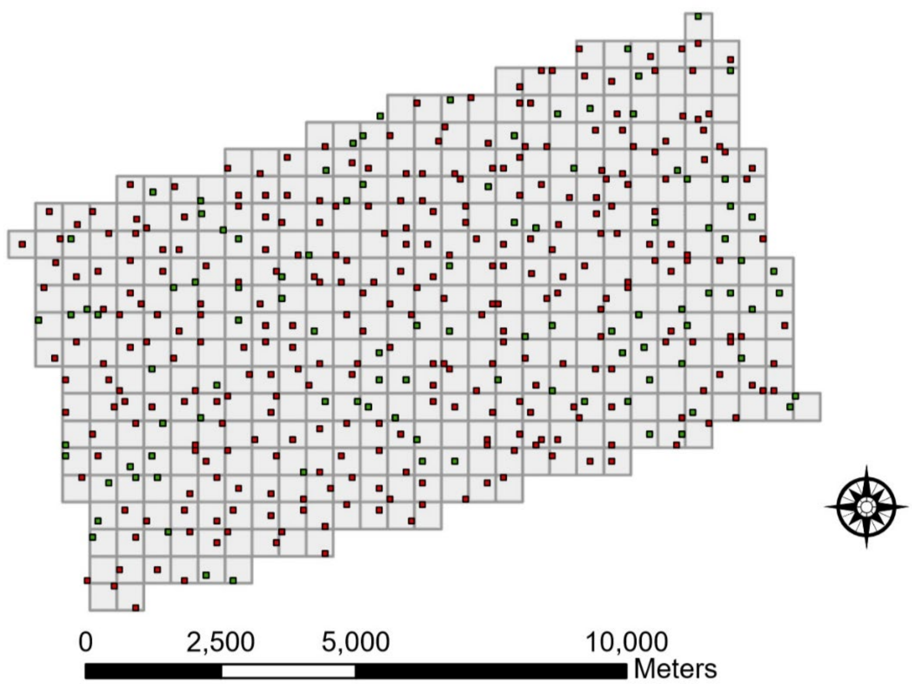

Figure 5.3 Map of the Piedmont with 1 hectare survey units showing presence (green) and absence (red) of archaeological materials.

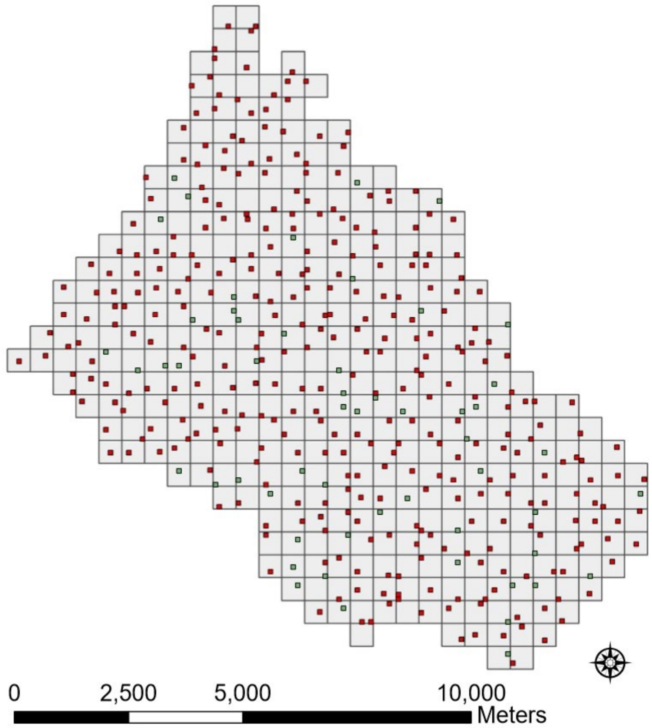

Figure 5.4 Map of the Highlands with 1 hectare survey units showing presence (green) and absence (red) of archaeological materials.

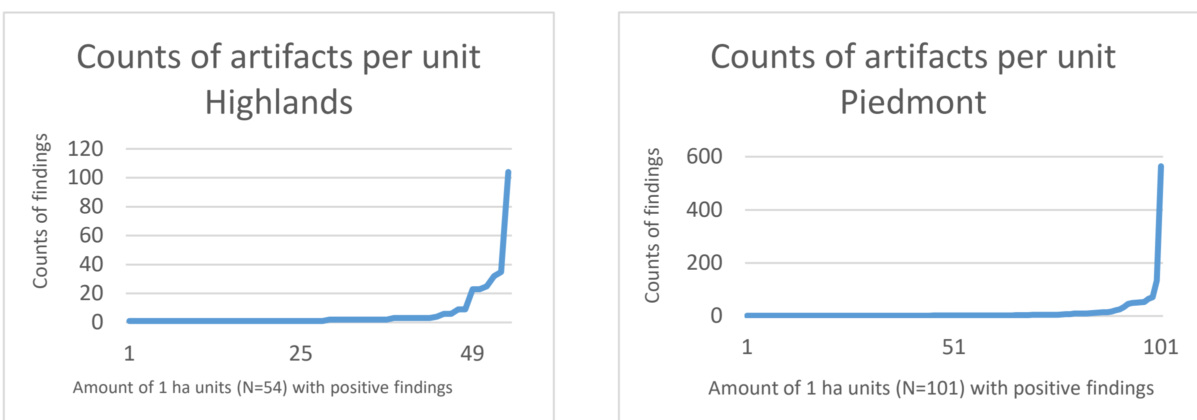

Figure 5.5 On the left, the x axis shows the 1-hectare-units with positive findings (N=54) from the Highlands and their counts of findings in the y axis. On the right, the x axis shows the 1-hectare-units with positive findings (N=101) from the Piedmont and their counts of findings in the y axis. The graphs indicate that the half of the units had one artifact, followed by units with low counts. In the Highlands the unit with more findings has around to 100 counts, while in the Piedmont the unit with more findings has around 550 counts.

Table 5.2 Area-density index for units in the Highlands.

Unit	Counts	Number of collection Points	Area squared meters	Density	Area in hectares	Area density
9	1	1	100	0.01	0.01	0.0001
10	35	1	100	0.35	0.01	0.0035
12	1	1	100	0.01	0.01	0.0001
15	6	1	100	0.06	0.01	0.0006
16	1	1	100	0.01	0.01	0.0001
38	1	1	100	0.01	0.01	0.0001
46	2	1	100	0.02	0.01	0.0002
53	1	1	100	0.01	0.01	0.0001
54	1	1	100	0.01	0.01	0.0001
59	1	1	100	0.01	0.01	0.0001
60	9	1	100	0.09	0.01	0.0009
64	23	1	100	0.23	0.01	0.0023
70	1	1	100	0.01	0.01	0.0001
80	113	19	1900	0.059	0.19	0.0113
89	1	1	100	0.01	0.01	0.0001
91	6	1	100	0.06	0.01	0.0006
92	2	1	100	0.02	0.01	0.0002
94	1	1	100	0.01	0.01	0.0001
95	23	1	100	0.23	0.01	0.0023
103	3	1	100	0.03	0.01	0.0003
110	3	1	100	0.03	0.01	0.0003
112	1	1	100	0.01	0.01	0.0001
116	1	1	100	0.01	0.01	0.0001
117	3	1	100	0.03	0.01	0.0003
122	2	1	100	0.02	0.01	0.0002
123	1	1	100	0.01	0.01	0.0001
124	1	1	100	0.01	0.01	0.0001
140	1	1	100	0.01	0.01	0.0001
157	1	1	100	0.01	0.01	0.0001
163	32	1	100	0.32	0.01	0.0032
164	2	1	100	0.02	0.01	0.0002
166	3	1	100	0.03	0.01	0.0003
173	9	2	200	0.045	0.02	0.0009
177	1	1	100	0.01	0.01	0.0001
179	1	1	100	0.01	0.01	0.0001
182	1	1	100	0.01	0.01	0.0001
186	25	2	200	0.125	0.02	0.0025

188	3	1	100	0.03	0.01	0.0003
197	1	1	100	0.01	0.01	0.0001
198	1	1	100	0.01	0.01	0.0001
211	3	1	100	0.03	0.01	0.0003
213	1	1	100	0.01	0.01	0.0001
217	1	1	100	0.01	0.01	0.0001
226	1	1	100	0.01	0.01	0.0001
230	1	1	100	0.01	0.01	0.0001
232	1	1	100	0.01	0.01	0.0001
238	2	2	200	0.01	0.02	0.0002
241	2	1	100	0.02	0.01	0.0002
242	1	1	100	0.01	0.01	0.0001
243	2	1	100	0.02	0.01	0.0002
244	1	1	100	0.01	0.01	0.0001
256	2	2	200	0.01	0.02	0.0002
263	4	1	100	0.04	0.01	0.0004
267	2	1	100	0.02	0.01	0.0002
Total	**349**	**76**	**7600**	**0.045**	**0.76**	**0.0349**

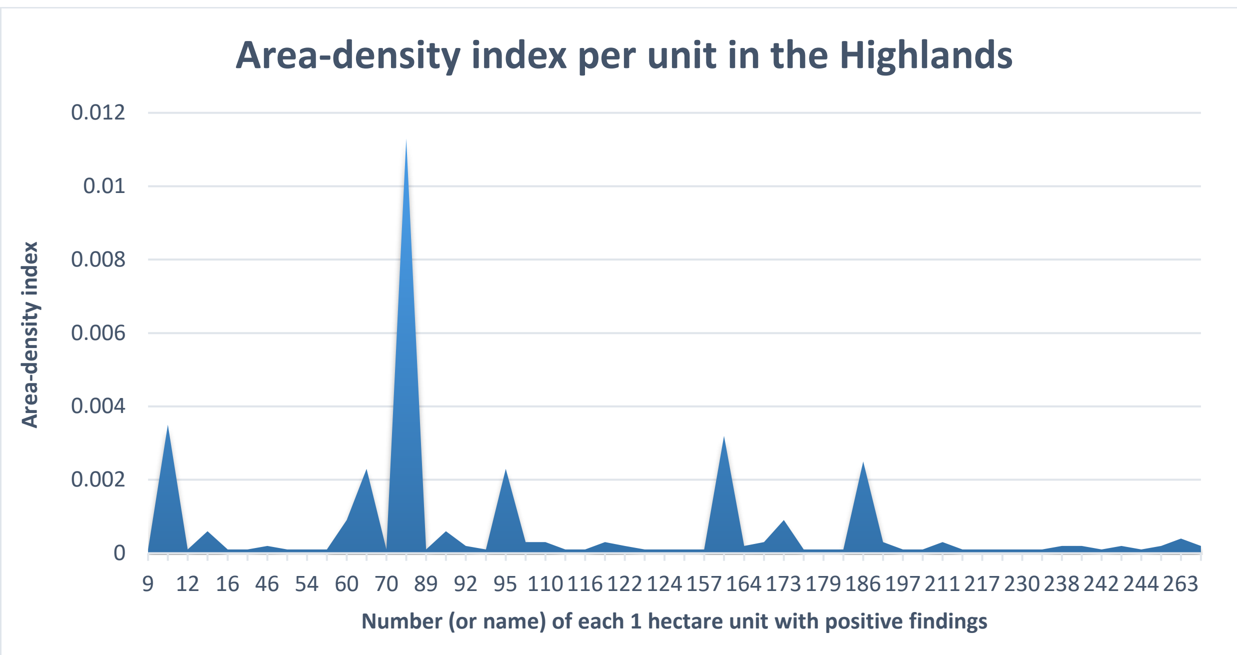

Figure 5.6 Area-density index per unit in the Highlands, y axis area-density index value, and x axis named-number of the unit.

Table 5.3 Area-density index for units in the Piedmont.

Unit	Counts	Number of collection Points	Area squared meters	Density	Area in hectares	Area density
1	4	1	100	0.04	0.01	0.0004
4	1	1	100	0.01	0.01	0.0001
9	6	1	100	0.06	0.01	0.0006
10	1	1	100	0.01	0.01	0.0001
18	1	1	100	0.01	0.01	0.0001
21	1	1	100	0.01	0.01	0.0001
23	2	1	100	0.02	0.01	0.0002
25	1	1	100	0.01	0.01	0.0001
26	7	2	200	0.035	0.02	0.0007
27	2	1	100	0.02	0.01	0.0002
28	2	1	100	0.02	0.01	0.0002
39	133	22	2200	0.060	0.22	0.0133
45	1	1	100	0.01	0.01	0.0001
53	1	1	100	0.01	0.01	0.0001
58	1	1	100	0.01	0.01	0.0001
61	1	1	100	0.01	0.01	0.0001
63	2	1	100	0.02	0.01	0.0002
69	1	1	100	0.01	0.01	0.0001
74	1	1	100	0.01	0.01	0.0001
75	1	1	100	0.01	0.01	0.0001
105	71	2	200	0.355	0.02	0.0071
111	2	1	100	0.02	0.01	0.0002
113	1	1	100	0.01	0.01	0.0001
115	564	8	800	0.705	0.08	0.0564
121	1	1	100	0.01	0.01	0.0001
123	1	1	100	0.01	0.01	0.0001
126	1	1	100	0.01	0.01	0.0001
132	1	1	100	0.01	0.01	0.0001
133	9	1	100	0.09	0.01	0.0009
134	1	1	100	0.01	0.01	0.0001
136	1	1	100	0.01	0.01	0.0001
137	1	1	100	0.01	0.01	0.0001
159	1	1	100	0.01	0.01	0.0001
161	9	3	300	0.03	0.03	0.0009
162	1	1	100	0.01	0.01	0.0001
173	1	1	100	0.01	0.01	0.0001
175	3	1	100	0.03	0.01	0.0003
177	1	1	100	0.01	0.01	0.0001

180	4	2	200	0.02	0.02	0.0004
182	2	1	100	0.02	0.01	0.0002
185	3	1	100	0.03	0.01	0.0003
186	1	1	100	0.01	0.01	0.0001
187	2	2	200	0.01	0.02	0.0002
190	1	1	100	0.01	0.01	0.0001
198	1	1	100	0.01	0.01	0.0001
201	65	1	100	0.65	0.01	0.0065
202	4	2	200	0.02	0.02	0.0004
208	2	1	100	0.02	0.01	0.0002
213	1	1	100	0.01	0.01	0.0001
214	1	1	100	0.01	0.01	0.0001
222	1	1	100	0.01	0.01	0.0001
227	1	1	100	0.01	0.01	0.0001
235	2	1	100	0.02	0.01	0.0002
236	2	2	200	0.01	0.02	0.0002
237	2	1	100	0.02	0.01	0.0002
242	2	1	100	0.02	0.01	0.0002
248	1	1	100	0.01	0.01	0.0001
252	1	1	100	0.01	0.01	0.0001
258	2	1	100	0.02	0.01	0.0002
260	1	1	100	0.01	0.01	0.0001
263	5	2	200	0.025	0.02	0.0005
264	46	4	400	0.115	0.04	0.0046
265	33	3	300	0.11	0.03	0.0033
266	21	2	200	0.105	0.02	0.0021
267	1	1	100	0.01	0.01	0.0001
284	3	1	100	0.03	0.01	0.0003
285	2	1	100	0.02	0.01	0.0002
292	1	1	100	0.01	0.01	0.0001
295	2	1	100	0.02	0.01	0.0002
296	14	1	100	0.14	0.01	0.0014
304	1	1	100	0.01	0.01	0.0001
309	16	3	300	0.0533	0.03	0.0016
317	11	2	200	0.055	0.02	0.0011
318	4	2	200	0.02	0.02	0.0004
320	53	4	400	0.1325	0.04	0.0053
323	1	1	100	0.01	0.01	0.0001
324	1	1	100	0.01	0.01	0.0001
337	14	2	200	0.07	0.02	0.0014
341	1	1	100	0.01	0.01	0.0001

345	1	1	100	0.01	0.01	0.0001
359	4	1	100	0.04	0.01	0.0004
365	1	1	100	0.01	0.01	0.0001
368	3	1	100	0.03	0.01	0.0003
369	13	2	200	0.065	0.02	0.0013
371	1	1	100	0.01	0.01	0.0001
372	50	3	300	0.166	0.03	0.005
373	2	2	200	0.01	0.02	0.0002
375	2	1	100	0.02	0.01	0.0002
376	2	2	200	0.01	0.02	0.0002
380	49	3	300	0.1633	0.03	0.0049
383	4	1	100	0.04	0.01	0.0004
384	2	1	100	0.02	0.01	0.0002
386	1	1	100	0.01	0.01	0.0001
387	12	1	100	0.12	0.01	0.0012
388	51	3	300	0.17	0.03	0.0051
389	25	2	200	0.125	0.02	0.0025
390	9	2	200	0.045	0.02	0.0009
391	9	1	100	0.09	0.01	0.0009
397	7	1	100	0.07	0.01	0.0007
401	1	1	100	0.01	0.01	0.0001
402	2	1	100	0.02	0.01	0.0002
Total	**1423**	**163**	**16300**	**4.91**	**1.63**	**0.14**

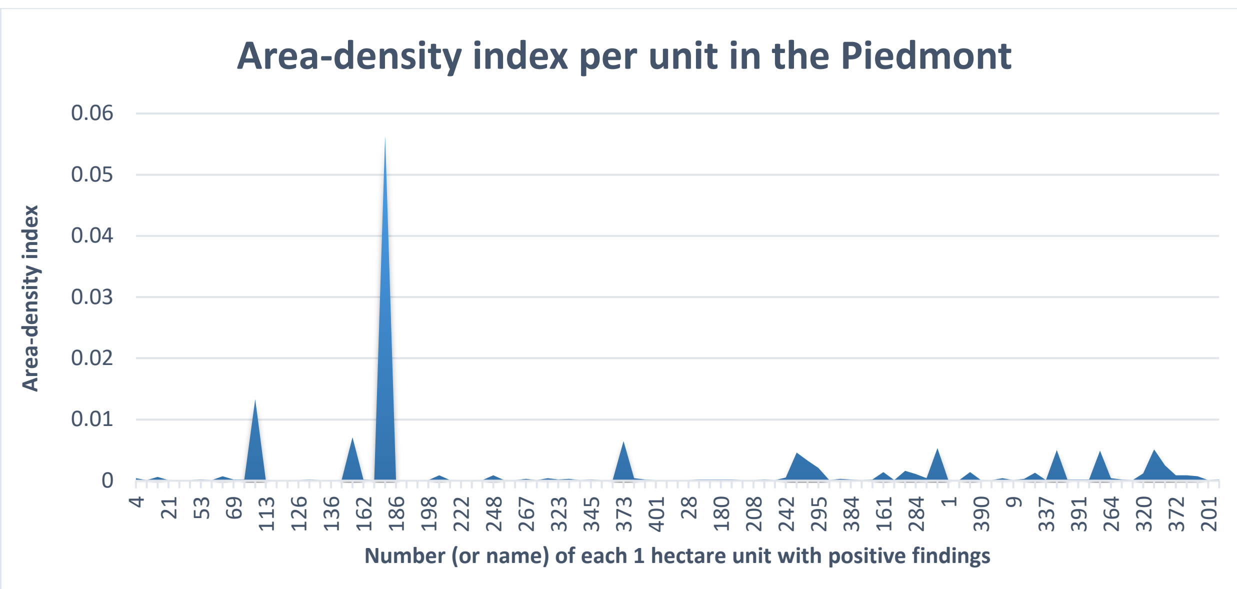

Figure 5.7 Area-density index per unit in the Piedmont, y axis area-density index value, and x axis named-number of the unit.

The procedure to prepare the data for the surfaces involved assigning the count values (number of artifacts collected in each 1-ha unit) to cells that represented the units with findings, and a value between -0.01 and -1 to cells that represented the units without findings. Then, I created a raster in Idrisi Selva adding a 0.01 value to all the cells that did not correspond to the sampling of 400 hectares, but instead represent the remaining 9,600 hectares cells for the area of 100 Km^2. The size of the cells was one hectare. I converted the raster to points to use the data in Surfer 13. The values and choices applied to the raster files attempted, for example in the Piedmont maps, to balance the large number of units with zero findings which were nearly 75% with a unit that had a count value greater than 500 archaeological artifacts.

In principle, surfaces with a higher power, such as 4, illustrate the patterns of findings in the sampling best. However, a lower smoothing power such as 0.001 averages the patterns at a local scale and therefore shows trends of the use of space across the ecological zone. The maps are *relative* representations of the densities of materials. To clarify, the Z values averaged with negative values do not represent the real counts.

In Figure 5.8, I observe two bumps in the Lowlands that correspond to two flakes. In the Piedmont I observe a large concentration at the intersection of the Diamante river with the Carrizalito stream. In addition, there are medium-sized concentrations across the river and a few in areas relatively further from courses of water. Towards the east I can also observe smaller bumps related to smaller sites. It highlights the articulation of these medium-smaller sites with the large concentration of materials. This suggests to me that the Piedmont contains large base camps, medium base camps, special task sites, and isolated findings. In the Highlands I find similar-sized concentrations across the Diamante river, and a bigger concentration next to the Perdido stream towards the southwest corner. I can also observe smaller bumps related to minor scatters of materials or isolated findings.

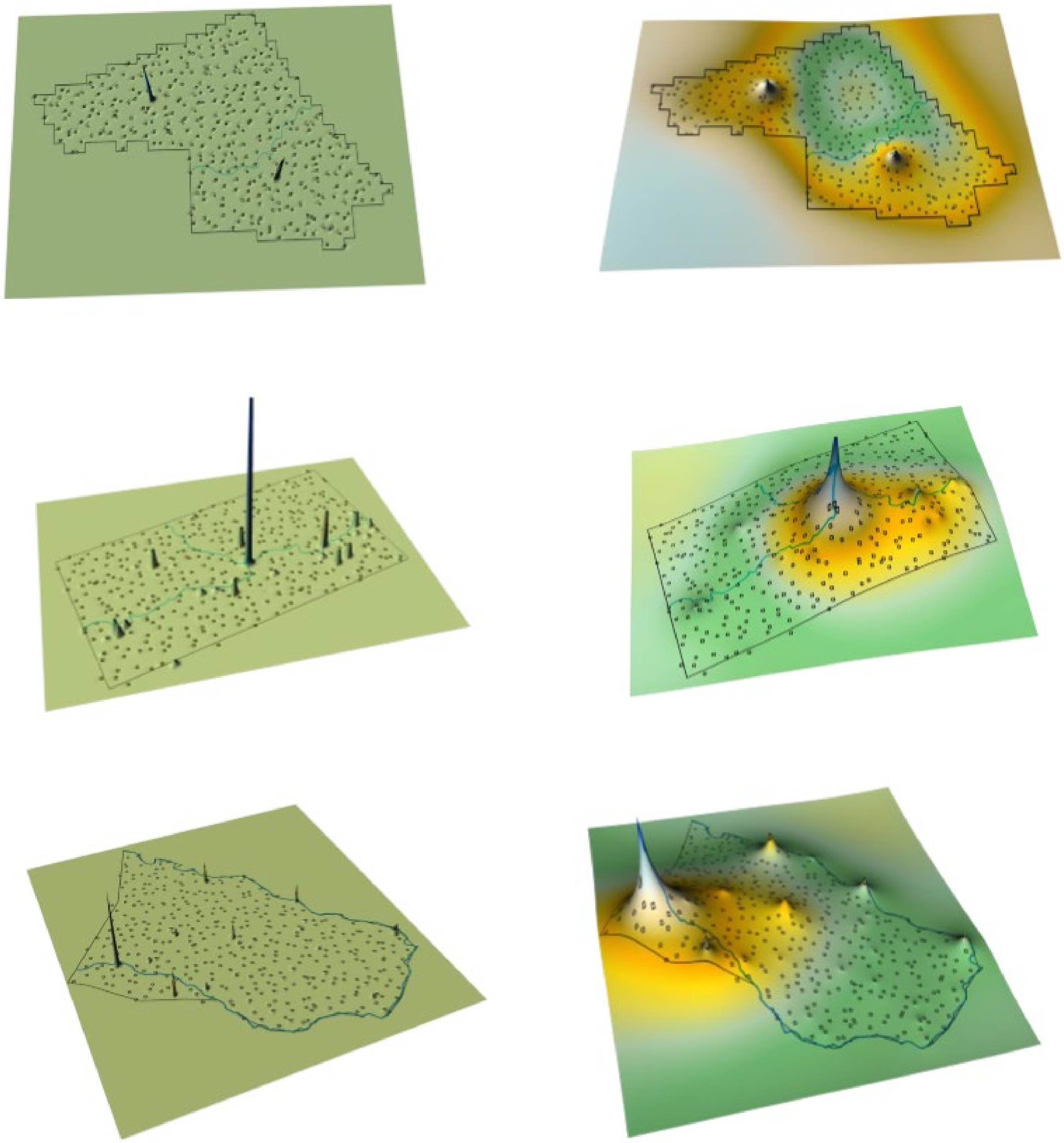

Figure 5.8 Maps of densities in the Lowlands (top), the Piedmont (center) and the Highlands (bottom): Inverse distance Power 4 (left) – Power 0.001 (right).

5.2 **Organization of lithic technology**

To explore how lithic technology was organized in the ecological zones I compare the use of raw materials, mainly basalts, cryptocrystalline and obsidian; the type or artifacts (tools, cores and debitage); the percentage of cortex; and metric measures of the artifacts. The amount of effort used in the manufacture of tools is critical to understand the production process. Some tools are simpler and require low effort in their production, therefore are mainly expediently manufactured (Andrefsky 1998). In contrast, other tools require many steps in their production, effort and time. These are called formalized tools (e.g. bifacial projectile points) and often require a reduction process which implies thinning a flake blank (stage one) till the final finished point (Stage five). The intermediate steps can be an edged biface (stage two), a thinned biface (stage three) and a preform (stage four) (Andrefsky 1998). Therefore, the amount of percentage of cortex, a variable that I consistently use, the metric variables in artifact types, the proportions of different cores types, tools types and debitage types, among other variables; can be used to explore different stages within the manufacturing process that can be related to an expedient use of a rock or involve a reduction sequence. What is more, it is possible to detect different stages of the reduction sequence across the landscape. This imply recognizing places of raw material acquisition, further reduction and the presence of the final products at certain places (e.g. is very common to find finished projectile points in base camps or special tasks camps).

I only found two chipped stone flakes in the Lowlands; therefore, this ecological zone will be not compared to the others at this point. I suggest that problems of visibility, site formation, changes in the actual and past courses of the Diamante River, or low human occupation must be taken into account to refine future survey methods in the Lowlands. To estimate the error ranges at different confidence levels of different categories of the archaeological materials found in the units I used the formula for sampling without repetition (Drennan 2009:243-247).

5.2.1 **Proportions of general artifact types**

Taken as a whole, the lithic assemblage of the Highlands consists of 6.2 % ± 3.2% tools, 3.2% ± 3.4% cores, and 90% ± 5.5% debitage at a 95% confidence level (Figure 5.9). In contrast, the lithic assemblage of the entire Piedmont consists of 2.5% ± 0.5% tools, 4% ± 3.7% cores, and 93.5% ± 3.8% debitage at a 95% confidence level (Figure 5.9). Cores are equally important to the organization of lithic technology in both ecological zones. In the Piedmont however, there is a slightly higher proportion of debitage and we can be certain of such difference at a 80% confidence level. In the Highlands there is a slightly higher proportion of tools, and we can be certain of such difference at a 95% confidence level (Figure 5.9). Also, the maps reveal that many of these tools are isolated findings (Figures 5.14, 5.15).

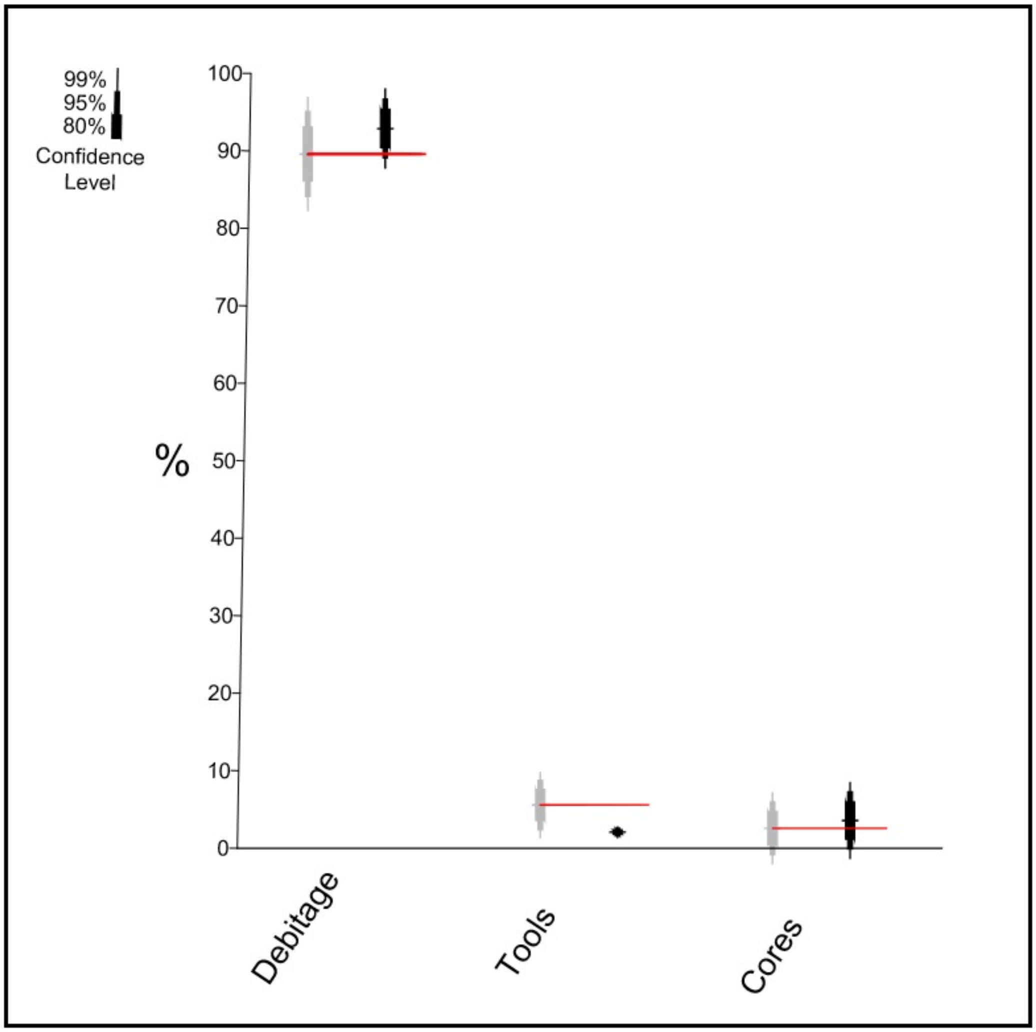

Figure 5.9 Bullet graphs of the proportions of distinct artifact types per ecological zone: Highlands (grey), Piedmont (black).

5.2.2 **Proportions of distinct raw material types**

The lithic assemblage of the Highlands consists of 65% ± 12% basalt, 30.5% ± 10% cryptocrystalline, and 4.5% ± 3.1% obsidian at a 95% confidence level. In contrast, the lithic assemblage of the Piedmont consists of 71.3% ± 9.5% basalts, 24.5% ± 9.6% cryptocrystalline, and 1.9% ± 1.2% obsidian at a 95% confidence level. In Figure 5.10, by observing the red line that crosses the bullet graphs from the proportion value, we can interpret that these differences in raw materials proportions are significant at the 80% confidence level for basalt and cryptocrystalline, while is significant at a 95% confidence level for obsidian.

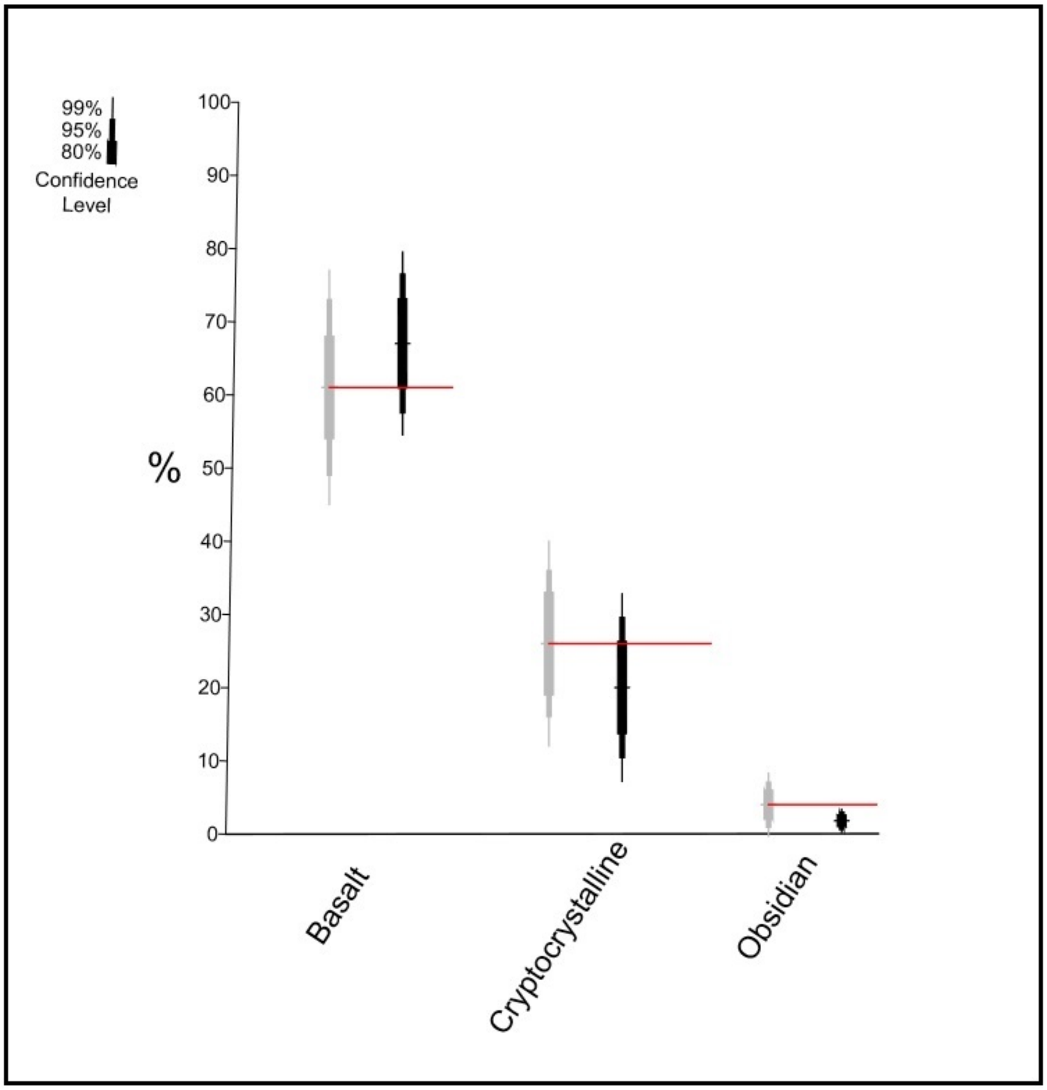

Figure 5.10 Bullet graphs of the proportions of distinct raw material types per ecological zone: Highlands (grey), Piedmont (black).

5.2.3 **Proportion of percentage of cortex**

Percentage of cortex in the Highlands indicates 71.2% ± 7.2% of 0% cortex, 24.7% ± 7% of 50% cortex and 4.1% ± 1.9% of 100% cortex at a 95% confidence level. In contrast, percentage of cortex in the Piedmont indicates 61% ± 12% of 0% cortex, 23.8% ± 5.9% of 50% cortex and 15.1% ± 5.9% of 100% cortex at a 95% confidence level. In Figure 5.11, by observing the red line that crosses the bullet graphs from the proportion value, we can interpret that these differences in percentage of cortex proportions are significant at the 80% confidence level for 0% cortex, are significant at a 95% confidence level 100% cortex, while have similar values for 50% cortex.

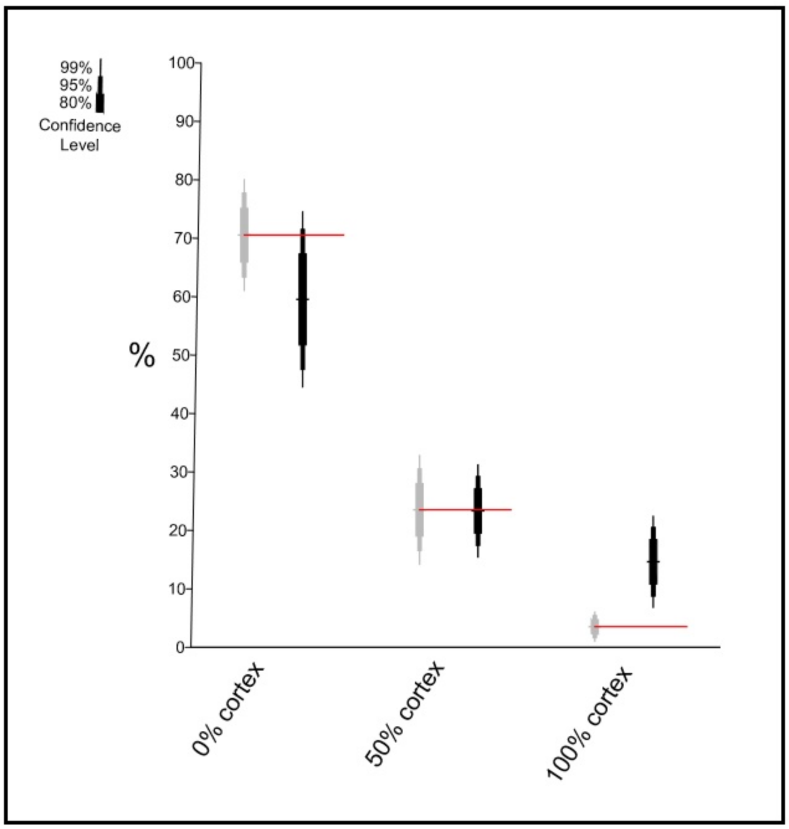

Figure 5.11 Bullet graph percentage cortex per ecological zone: Highlands (grey), Piedmont (black).

5.2.4 **Averages of metric variables in lithic artifacts**

To compare the averages, with different confidence levels, of the metric variables in millimeters and grams of the lithic assemblages of the Piedmont and the Highlands, I used the formula to estimate population means in sampling without repetition as stated by Drennan (2009:247). The metric measures for lithic materials differ substantially, being larger in the Piedmont. The average length is 40.1mm ± 11mm in the Piedmont and 27.7mm ± 15.8mm in the Highlands at a 95% confidence level. The average width is 33mm ± 8.2 in the Piedmont and 25.1mm ± 9.9mm in the Highlands at a 95% confidence level. The average thickness is 13.8mm ± 5mm in the Piedmont and 9.3mm ± 6.18mm in the Highlands at a 95% confidence level. The average weight is 34gr ± 21.3gr in the Piedmont and 9.3gr ± 10.1 in the Highlands at a 95% confidence level. As observed in Figure 5.12, these differences in artifact size are significant for all the variables described, indicating a higher intensity of raw material use in the Highlands.

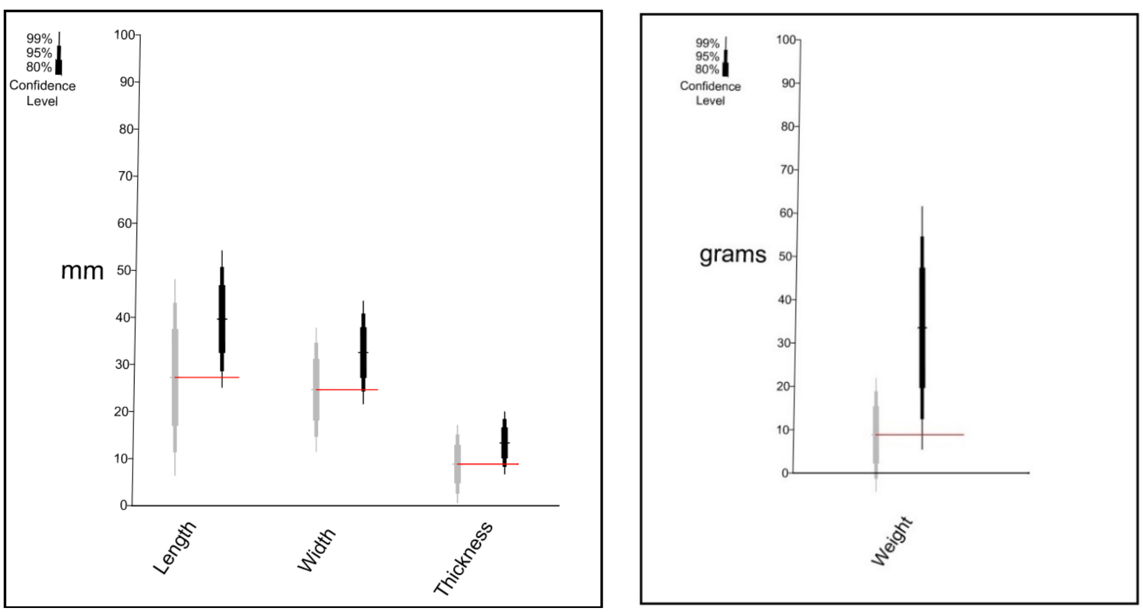

Figure 5.12 Bullet graphs with metric values for length, width, and thickness in mm; weight in grams, for the Highlands (grey) and the Piedmont (black).

In figures 5.13- 5.14 we observe that cryptocrystalline raw materials are concentrated mainly at the intersection of the Diamante River and Carrizalito stream. However, we can also observe some peaks that are 500, 1,000, and 2,500 meters away from water sources. There are also some little bumps throughout the ecological zone. In this map we clearly observe that basalt procurement was close to the Diamante River. Even if the larger concentration of basalt artifacts occurs at the intersection of the Diamante River and the Carrizalito stream, it highlights that the raw material is not only associated with the stream. We see obsidian in the larger sites—equipped with better raw materials and technology due to longer anticipated use-time.

In the Highlands the basalts occur mainly in small-to-medium size sites across the Diamante River and in the southwest corner close to Perdido stream. The cryptocrystalline materials also appear in this location. Obsidians appear in two different peaks both near the Diamante and Perdido streams towards the west of the ecological zone (Figures 5.13- 5.14, down).

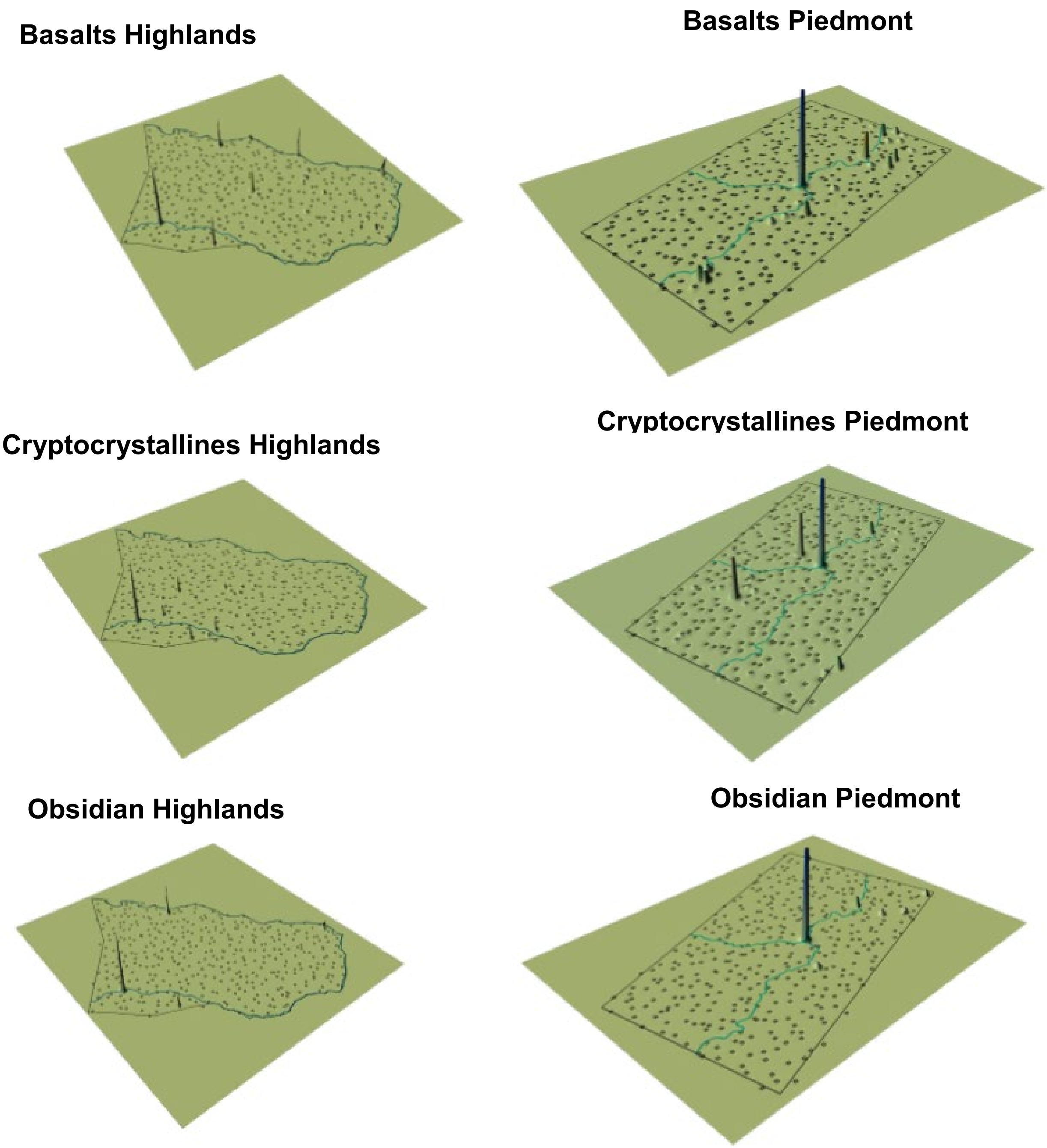

Figure 5.13 Maps of raw material densities in the Piedmont (right) and the Highlands (left): basalts (top), cryptocrystalline (center), obsidian (bottom)- Power 4.

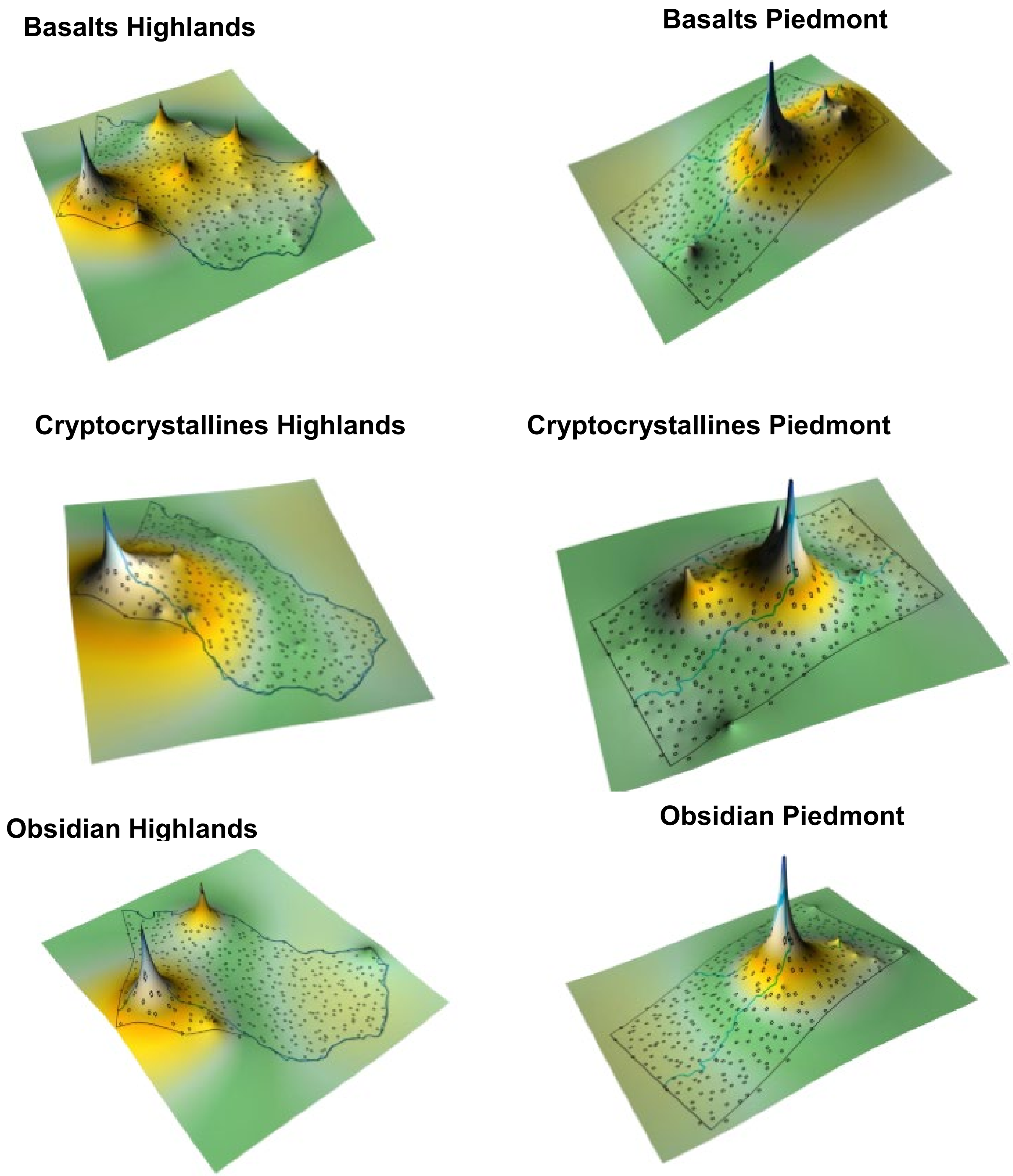

Figure 5.14 Map of raw materials densities in the Piedmont (right) and the Highlands (left): basalts (top), cryptocrystallines (center), obsidian (bottom)- Power 0.001.

Figures 5.15-5.16 illustrate the distribution of tool types in each ecological zone. In the Piedmont, interestingly, tools are present not only in the larger concentration but also in some peaks towards the east. In addition, as represented by many peaks not only in the east but across both the Diamante River and Carrizalito stream, the number of cores shows a considerable emphasis in the use of local raw materials throughout the Piedmont. In the Highlands, the proportion of cores is lower, and they are most abundant in the central area of the ecological zone. Both areas show that tools represent no more than 5% of the lithic artifacts in the different locations that exhibit scatters of materials.

In figures 5.17- 5.18 we observe that flakes with no cortex (i.e. 0% cortex) in the Piedmont (top, right) occur mainly in the larger concentrations of artifacts near the Diamante river and the Carrizalito stream. Some other peaks and bumps are mainly close to the river. In contrast, in the map of flakes covered by 50% cortex (center, right) we observe other peaks that might reveal places where the raw materials were acquired, as these pieces are only in the intermediate stages of the stone tool manufacturing sequence. In the map of flakes completely (i.e. 100%) covered in cortex (down, right), we observe many locations where raw materials were most certainly acquired. It is important to keep in mind that these flakes are produced in the first stages of lithic core reduction, while the dorsal side is completely covered with cortex, the internal side is a marker for removal of a detached piece from an objective piece by percussion. This confirms that secondary sources of raw materials (mainly redeposited basalt cobbles) were abundant in the Piedmont and that people exploited them frequently.

The distribution and density of debitage, tools and cores suggest a high use of locally available raw materials with the use of secondary sources in the proximities of larger sites. It highlights an increased abundance of cores in relation to tools—as well as the high percentages of cortex—in the Piedmont.

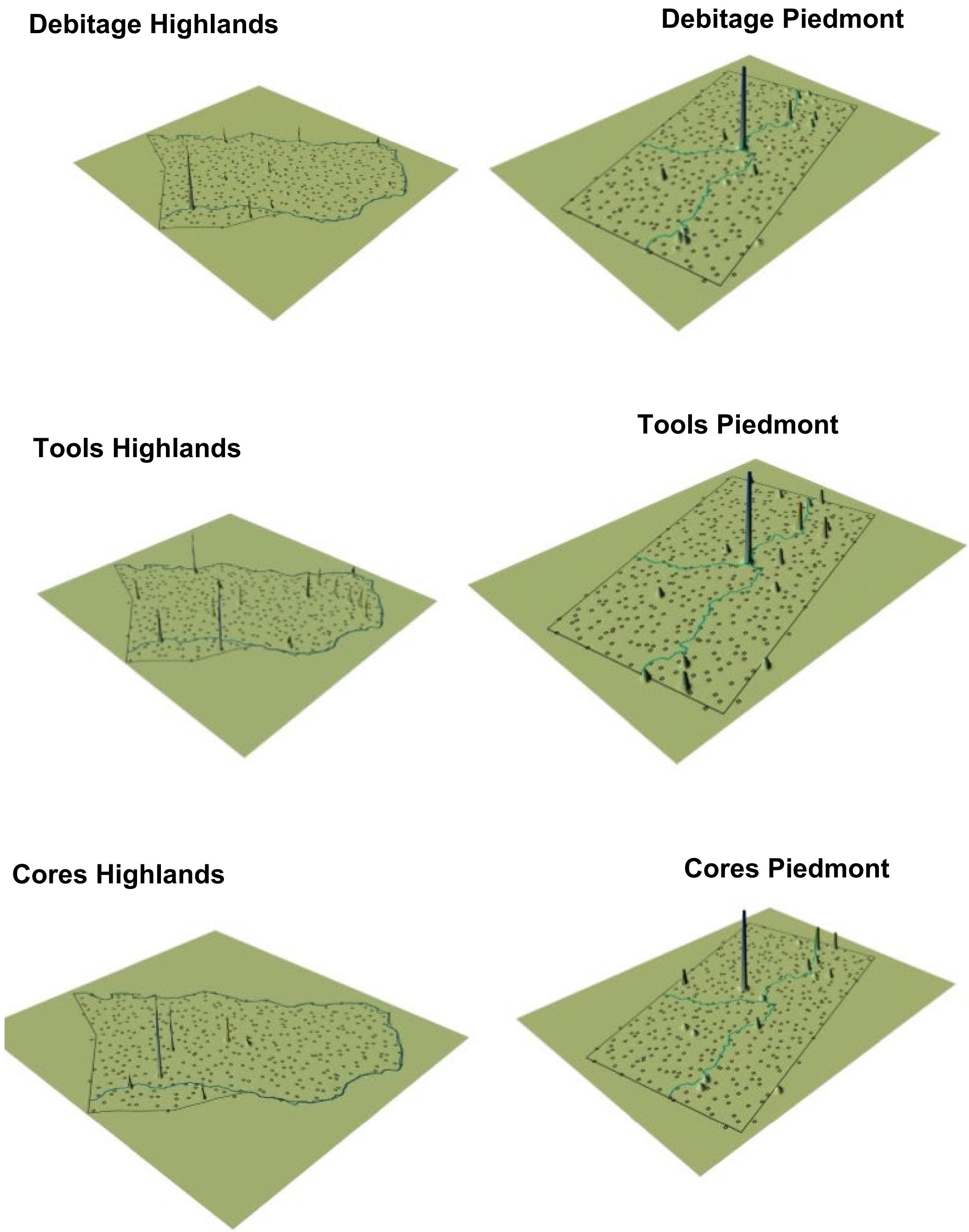

Figure 5.15 Map of artifact type densities in the Piedmont (right) and the Highlands (left): Debitage (top), tools (center), cores (bottom)- Power 0.001.- Power 4.

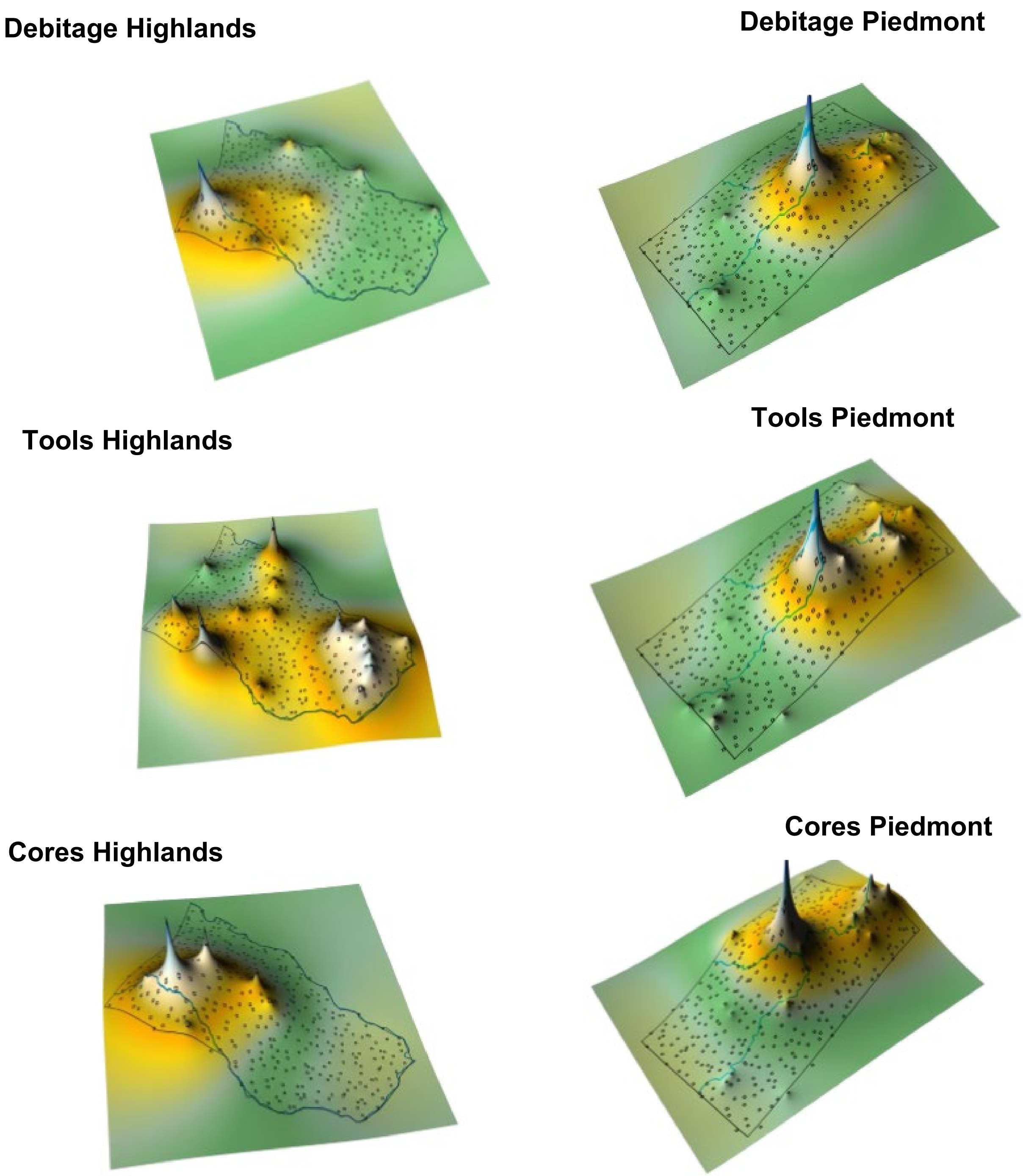

Figure 5.16 Map of artifact type densities in the Piedmont (right) and the Highlands (left): Debitage (top), tools (center), cores (bottom)- Power 0.001.

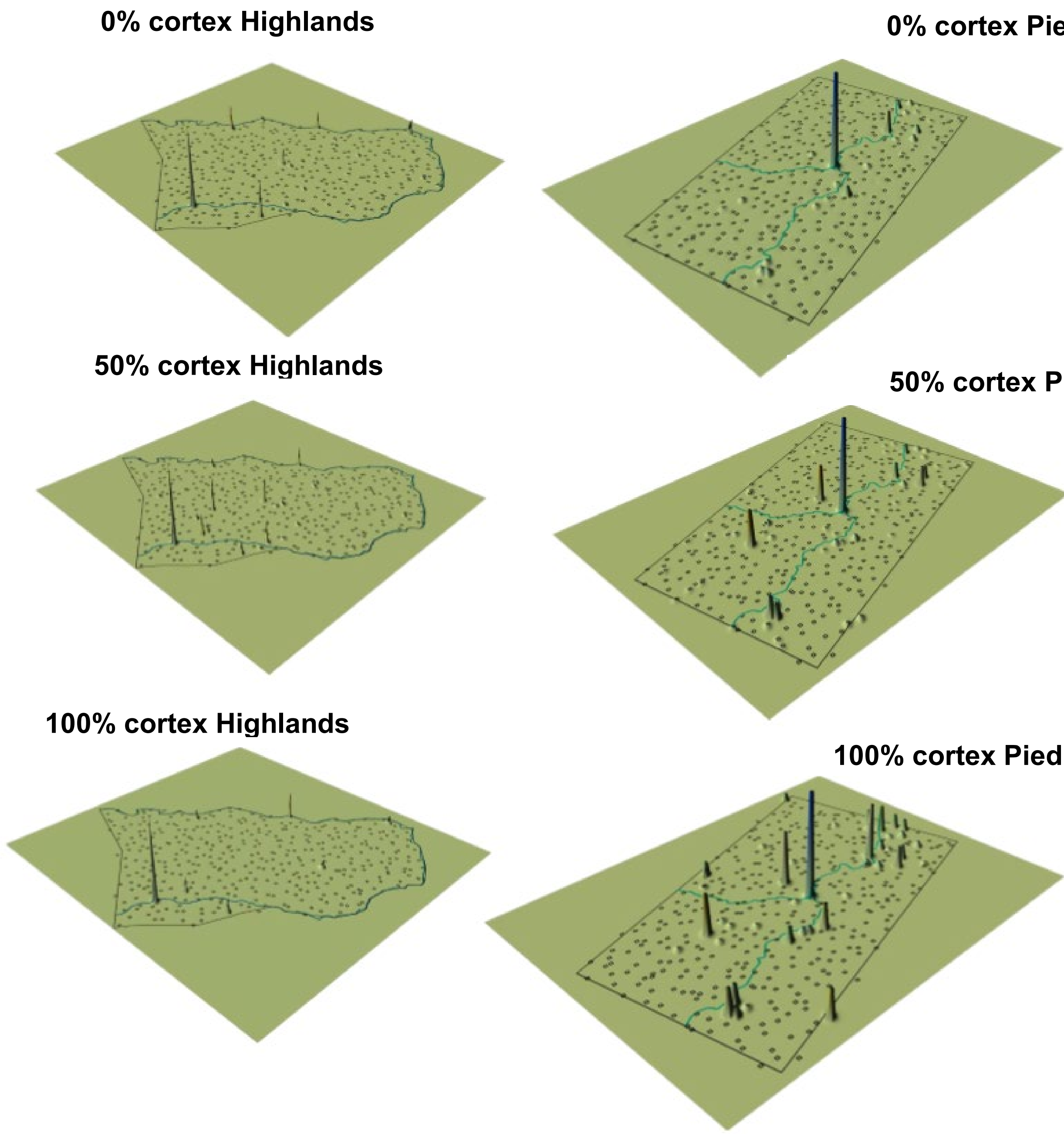

Figure 5.17 Map of the density of flakes covered by different amounts of cortex, in the Piedmont (right) and the Highlands (left): 0% cortex (top), 50% cortex (center), 100% cortex (bottom)- Power 4.

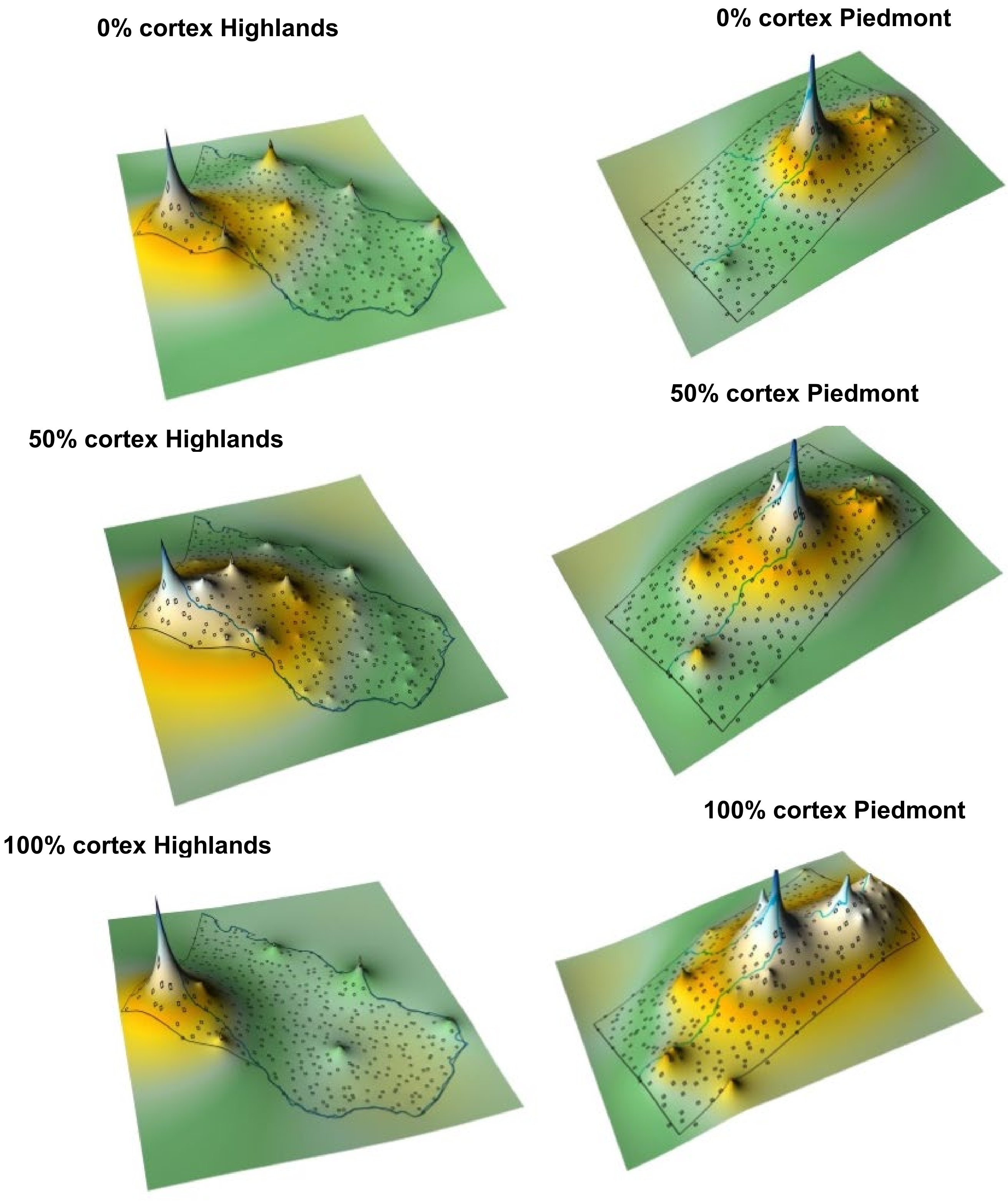

Figure 5.18 Map the density of flakes covered by different amounts of cortex, in the Piedmont (right) and the Highlands (left): 0% cortex (top), 50% cortex (center), 100% cortex (bottom)- Power 0.001.

5.2.5 **Debitage**

In this section I analyze debitage by looking at the abundance of flake types, the distribution of their size (e.g. lenght x weight/2), the kinds of platforms, the raw materials and percentage of cortex. The objective is to explore in finer detail these variables to detect other markers of intense use of raw materials between the Piedmont and the Highlands.

Table 5.4 Frequencies and proportions of debitage type per ecological zone.

Debitage type	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Angular	222	72.4	862	64.9
Core flake	25	8.2	63	4.7
Microflake	2	0.7	0	0.0
Primary	7	2.3	116	8.7
Secondary	40	13.1	280	21.1
Not determined	10	3.3	8	0.6
Total	306	100	1329	100.0

The Piedmont sample (N=1329) produced four times the number of debitage than the Highlands (N=306) (Table 5.4). Within the categories of debitage type, the proportions indicate that the Highlands has fewer secondary (13.1%) and primary (2.3%) flakes, than the Piedmont, which has 21.1% secondary flakes and 8.7% primary flakes. Angular flakes, internal-tertiary kinds of flakes, tend to be associated with tools production—and therefore with the last stages of the reduction sequence. The proportion of angular flakes in the Highlands (72.4%) is slightly higher than in the Piedmont (64.9%). For each debitage type, the Piedmont has higher average of lenght x width/2—a measure that in my opinion synthetizes two metric variables straightforward enabling clear comparison regarding size among dissimilar-shaped items such as debitage—values that are 50-100% greater than those in the Highlands (Table 5.5).

Table 5.5 Averages of lenght x width/2 by flake type in each ecological zone.

Average of lenght x width/2		
Debitage type	Highlands	Piedmont
Angular	283.1	359.5
Core Flake	397.8	746.4
Microflake	28.5	
Primary	340.0	746.7
Secondary	412.4	567.4

Striking platforms are the surface area on a lithic piece that receives the hit during tool production. Often, the platform is removed with the detached piece, indicating where the force was applied (Andrefsky 1998). Platform preparation in stone tool making permits us to infer investment in the manufacture sequence (Andrefsky 1998). The Highlands has 5.6% of regularized platforms—those surface areas that have been extra prepared during tool knapping to enhance efficacy at the moment to apply force to detach a piece. In contrast, the Piedmont has 0.5% of regularized platforms (Table 5.6). In addition, 10.5% of the Highland platforms are complex in contrast to 0.8% of the Piedmont platforms; and 6.5% of the Highland platforms are cortical compared to 13.3% of the Piedmont platforms (Table 5.7). This trend clearly demonstrates a higher amount of preparation and time dedicated to platforms during tool-knapping in the Highlands. Interestingly there are no differences in the ordinal scale of flake scars between the two ecological zones (Table 5.8).

Table 5.6 Regularized and non-regularized platforms in each ecological zone.

Regularized Platform	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
No	289	94.4	1322	99.5
Yes	17	5.6	7	0.5
Total	306	100	1329	100.0

Table 5.7 Platform type in each ecological zone.

Platform type	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Cortical	20	6.5	177	13.3
Complex	32	10.5	11	0.8
Flat	215	70.3	1076	81
Missing	39	12.7	65	4.9
Total	306	100	1329	100

Table 5.8 Ordinal scale for flake scars in each ecological zone.

Flake Scars Ordinal	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
1	63	20.6	304	22.9
2	125	40.8	532	40.0
3	107	35.0	429	32.3
Undet.	11	3.6	64	4.8
Total	306	100	1329	100

In the Piedmont the raw materials show that most of the debitage is basalt (72.6%), followed by cryptocrystalline (23.7%), obsidian (1.7%), and others (2.0%). The percentage of flakes covered by different amount of cortex is 62.8% (0% coverage), 23.2% (covered by 0.1-50%) and 14% (covered by 51-100%). In the Highlands the raw materials that most debitage is basalt (67.6%), followed by cryptocrystalline (28.4%), and obsidian (3.9%). The percentage of cortex is 73.9% (0), 21.9% (0.1-50) and 4.2% (51-100) (Tables 5.9- 5.10).

Table 5.9 Raw materials for debitage in each ecological zone.

Raw Materials	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Basalts	207	67.6	965	72.6
Cryptocrystalline	87	28.4	315	23.7
Obsidians	12	3.9	23	1.7
Others	0	0	26	2.0
Total	306	100	1329	100

Table 5.10 Percentage of cortex on debitage in each ecological zone.

Percentage of cortex	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
0	226	73.9	835	62.8
50	67	21.9	308	23.2
100	13	4.2	186	14.0
Total	306	100	1329	100

In sum, the variables of debitage demonstrate a significant trend of more intense use of raw materials in the Highlands. We observe: a diminished size for all debitage in all the measures taken; platforms indicating more preparation in the Highlands to ensure performance during stone tool making; higher proportions of cortex in the Piedmont, which indicates local procurement and possibly a corridor of transport towards the Highlands, in which we find the last stages of the reduction sequence. Raw material proportions are somewhat similar, but highlight the lower proportion of obsidian in both environmental zones, which indicates a preference for locally available raw materials.

5.2.6 **Cores**

The Piedmont does not present any exhausted cores while the Highlands present 5 exhausted cores. Andrefsky (1998) discuss that to compare different cores sizes, that tend to have dissimilar shapes, it is plausible to use length of the piece multiplied by weight. I consider adding width as an extra indicator of possible volume, always considering that the shapes of cores present great variability. The average size of cores (Lenght x Width x Weight- in mm and grams) contrasts drastically with a difference 32 times larger in the Piedmont (3,224,082) compared to the Highlands (105,664).

As mentioned in chapter 4, I classify cores in unidirectional, bidirectional and multidirectional, following (Andrefsky 1998). Unidirectional cores show evidence of flakes extraction in one face of the rock, which has been related to expedient use. Bidirectional and multidirectional cores tend to demonstrate two or multiple faces of the rock with evidence of flake extraction; and has been associated to higher intense use of the raw material (Andrefsky 1998).

In the Piedmont, there are multiple core types: 75.4% of them unidirectional, 22.8% bidirectional and 1.8% multidirectional (Table 5.11). And these cores are made from a variety of raw materials: 45.6% from cryptocrystalline, 45.6% from basalt and 8.8% from other raw materials (Table 5.12). The percentage of cores covered in various amounts of cortex is 2.0% (for those with no cortex), 43.5% (covered 1-50%) and 54.5% (covered in 51-100%) (Table 5.13). In the Highlands the types of cores are 38.5% unidirectional, 38.5% bidirectional, and 23.1% multidirectional (Table 5.11). The raw materials indicate values of 92.3% cryptocrystalline and 7.7% basalt (Table 5.12). The percentage of cortex is 7.7% (0), 84.6% (0.1-50) and 7.7% (50-100) (Table 5.13). Negative flakes removed were also grouped in an ordinal scale as with flake scars in debitage. The Piedmont and the Highlands have similar proportions of negative flakes (Table 5.14).

In summary, the frequency of cores is higher in the Piedmont, showing significantly larger size. Less intensity of use is demonstrated by these trends: higher values of unidirectional cores; higher amounts of cortex; no exhausted cores; and local raw materials procurement. We did not encounter any cores made from obsidian in either environmental zone, indicating that this raw material was imported in the final stages of reduction, or perhaps as tool blanks (Kelly 1983). This is consistent with the presence of projectile points made of obsidian and flakes that are related to retouch and the final stages of production as they do not present any cortex.

Table 5.11 Frequencies and proportions of cores type per ecological zone.

Core Type	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Bidirectional	5	38.5	13	22.8
Multidirectional	3	23.1	1	1.8
Unidirectional	5	38.5	43	75.4
Total	13	100	57	100

Table 5.12 Frequencies and proportions of raw material in cores in each ecological zone.

Core Raw Material	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Basalts	1	7.7	26	45.6
Cryptocrystalline	12	92.3	26	45.6
Others	0	0	5	8.8
Total	13	100	57	100

Table 5.13 Frequencies and proportions of percentage of cortex in cores in each ecological zone.

Percentage of cortex	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
0	1	7.7	2	3.5
50	11	84.6	26	45.6
100	1	7.7	29	50.9
Total	13	100	57	100

Table 5.14 Negative flakes removed from cores in each ecological zone.

Negative Flakes removed	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
1	2	15.3	8.8	5
2	0	0.0	15.8	9
3	11	84.7	75.4	43
Total	13	100	57	100

5.2.7 **Tools**

All the size and weight variables of tools indicate that the Piedmont had higher values that range from 50% to 100% more than in the Highlands (Table 5.15). In the Piedmont, most tools were projectile points (44.4%) and scrapers (47.2%) (Table 5.16). The main raw material used is basalt (63.9%), followed by cryptocrystalline (22.2%), obsidian (11.1%), and other raw materials (2.8%) (Table 5.17). In contrast, in the Highlands most tools were projectile points (81.0%) and scrapers (9.5%) (Table 5.16). The main raw material used is basalt (61.9%), followed by cryptocrystalline (23.8%), and obsidian (14.3%) (Table 5.17).

In sum, the tools have larger sizes in the in the Piedmont, evidenced by the contrasting differences in all the metric variables regarding size and weight. In addition, these findings highlight the differences in the number of scrapers between the ecological zones. Salgán (2013), argues that that higher rates of scrapers would suggest higher intensity of use at locations that are persistently used for a longer period of time. Finally, the proportions of raw materials used in tools are similar between the Piedmont and the Highlands.

Table 5.15 Averages of lenght x width/2 and general metric measures of tools in each ecological zone.

Measure	Highlands	Piedmont
Lenght*width/2	279.4	537
Lenght	28.1	38.1
Width	18.9	26
Thickness	5.6	8.5
Weight	3.6	10.1

Table 5.16 Frequencies and proportions of tools type per ecological zone.

Raw Material	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Bimarginal tool	0	0.0	2	5.6
Preform	1	4.8	1	2.8
Projectile point	17	81.0	16	44.4
Scraper	2	9.5	17	47.2
Total	21	100.0	36	100.0

Table 5.17 Frequencies and proportions of percentage of raw materials in tools in each ecological zone.

Raw Material	Highlands		Piedmont	
	Frequency	Proportion	Frequency	Proportion
Basalts	13	61.9	23	63.9
Cryptocrystalline	5	23.8	8	22.2
Obsidians	3	14.3	4	11.1
Others	0	0.0	1	2.8
Total	21	100.0	36	100.0

5.3 **Ceramics and milling stones**

In this section I report the findings of ceramics and milling stones within the one hectare units. The sample is too small to elaborate any sophisticated analysis, but I will describe the main characteristics and give them an interpretation under the scope of the research questions. From the sampling units, only unit 80 in the Highlands had evidences of 9 ceramic fragments. In the variable firing there are 6 fragments with incomplete oxidation and 3 fully oxidized. I argued that within the firing variable, incomplete oxidation and fully oxidized represent low investment in comparison to reduced firing. Therefore, for the variable firing, the ceramics fragments indicate low investment. I established that finer temper size relates to higher investment, as they represent selection and preparation before its addition to the clay. With regards to temper size, 1 fragment had large temper and the rest medium-sized temper, therefore there was low investment for this variable. For surface treatment, 7 had been smoothed, 1 polished, and 1 brushed. Brushed is simply the technique of passing a straw brush over the piece—in southern Mendoza is a surface treatment typically found in the style Atuel Cepillado (Neme 2007). I argued for surface treatment, that smoothed represent low investment in comparison to polished and even brushed. Therefore, for the variable surface treatment, there is also low investment. Finally, for styles there are 6 Overo and 6 Marron Pulido. Neme (2007) considers these styles as local from sourthen Mendoza. However, the discussion of whether Marron Pulido relates to styles in Chile is open (Neme 2007; Sugrañes and Franchetti 2012; Falabella et al. 2001).

The ceramic characteristics imply that there was a low investment in this technology since there is predominant smoothed as surface treatment, medium temper size and oxidized firing. This is consistent with the suggestions from the ceramic technological investment model for marginal environments (Sturm et al. 2016). In the context of summer camps, it was hard for hunter gatherers to spend the time to invest in ceramics when there were other activities that were more important for subsistence.

Finally, only 3 milling stones were found in the Piedmont and 3 milling stones were found in the Highlands. The few amounts recovered may be due to crew member bias: more than 25 crew members participated in the survey with different degree of expertise in archaeology. While I got assure that always the pairs of crew members would have someone experienced, I cannot be certain that they knew what they were looking for in terms of milling stones. The amount of milling stones is so little that I tend to think that I may have failed in calling attention regarding millings stones while I explained the methodology in the field. In short, the few ones that appeared are in sites, correlated with the presence of ceramics and some obsidian, following the logic of catch and reuse of these materials.

In summary, the Piedmont indicates a higher intense use in comparison to the Highlands. The Lowlands showed extremely little findings suggesting low human occupations or problems in visibility and site formation processes. The main variables of lithic organization indicate that basalts were the most used raw material, followed by cryptocrystalline and obsidian (which is mainly present in larger sites). The high amounts of percentages of cortex suggest that it was common to do quarrying activities in the Piedmont from which raw materials circulated to the Highlands in smaller sizes, as was evident from the averages of all metric variables of all the artifact types. The archaeological sites tend to cluster near the water curses and in proximities to larger raw material sources, as in evident in the settlement pattern of the piedmont inclined towards the east. In the Piedmont the larger occupation occurs in the intersection within Carrizalito stream and the Diamante river, while in the Highlands, the larger occupation occurs close to the Perdido stream. Besides the larger sites I could detect different medium-size locations related to specific tasks, in the Piedmont these were more related to quarrying while in the Highlands to hunting parties. This pattern leads me to the need to explore the differences and similarities in the site structure within the ecological zones, to understand better the complementary use of the ecological zones across the Diamante valley. A task attempted in the following chapter.

6.0 Archaeological assemblages within the ecological zones

To compare human land use between the Highlands and the Piedmont at a lower scale, I explored the composition of findings and sites within each ecological zone. The objective of this chapter is to identify differences in the settlement patterns that may be indicative of substantial differences in the organization of subsistence between the ecological zones. In this chapter I synthetize the information available for findings both in units and between-units. First, I present in sections 6.1 and 6.2 the location and densities of these archaeological assemblages. I also report the frequencies and percentages of the main variables for lithic organization (raw material type, artifact type and percentage of cortex) in the units, between-units and the sample of all (sum of units and between-units) of the Piedmont and the Highlands. Second, I report in section 6.3 the results of the lithic organization (raw material type, artifact type, and percentage of cortex) for 24 archaeological sites from the Piedmont and the Highlands that had more than 25 archaeological materials. Third, I explore in section 6.4 the length of stays in sites by addressing "persistent places" using as proxies different ratios among lithic assemblages: Local-non::local debitage; local debitage::non-local tools; minimum number of flakes (MNF) to core ratio; non-cortical flake to cortical flake; and unmodified flake to tool ratio. Fourth, I discuss in section 6.5 the similarities and differences among sites using statistical tools, such as coefficients of similarities and cluster analysis, to generate site-groups. Fifth, I report in sections 6.6 and 6.7 the findings of all ceramic materials found in the survey and compare them to ceramic assemblages from other archaeological sites of the Diamante valley: rockshelters, Risco de los Indios, and El Indígeno.

The maps presented in this chapter differ from the surfaces in chapter 5 because the information between-units is biased and therefore the interpolations generated would be biased as well. Even if we could argue that crew members and therefore the data they produced followed the distribution of the units placed in blocks of 25 hectares, I did not record the tracks to report zones where I am sure that there were no findings. And even by doing so, we would have to discuss the validity of such information (between-units and the tracks indicating lack of findings) and the persistency of biases due to logistics, the use of streams to walk between units, among many other reasons. For these reasons I report the location of the findings, and the distribution of densities with points.

6.1 **Lithic findings within units and between units**

In addition to the findings in the units, I collected the archaeological materials between units as well. In chapter 4 the methodology of this procedure is described. The collection of these materials allowed the identification of larger boundaries of the sites targeted in some of the units, in addition to the identification of new sites, scatters of materials and isolated findings (Figures 6.1, 6.2). For clarity, the frequency and percentages of the findings, both within and between units, as well as the total number of findings, are presented for the following variables: artifact type, raw material, and percentage of cortex in both the Highlands and the Piedmont (Tables 6.1-6.6).

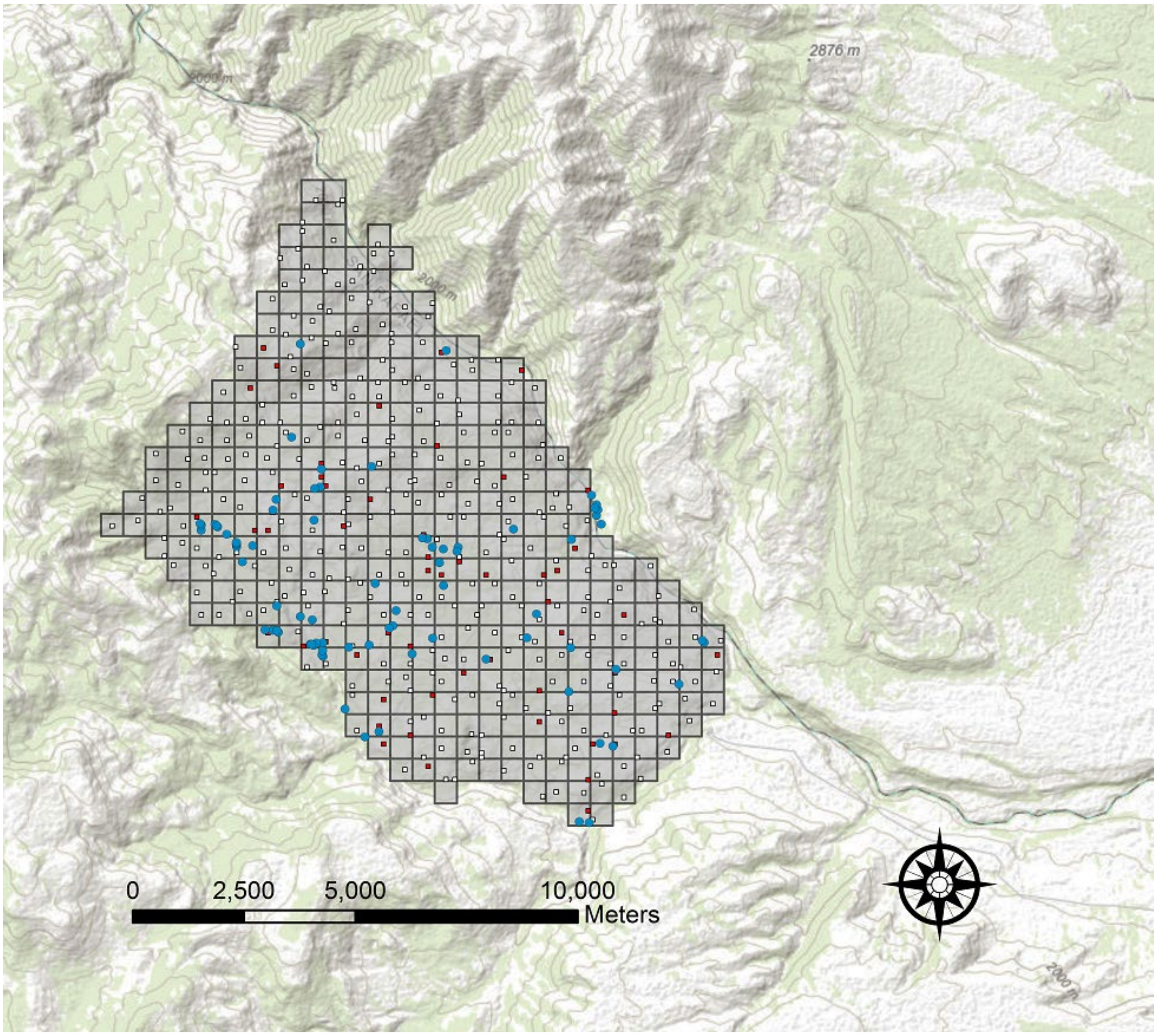

Figure 6.1 Map of the Highlands showing locations with archaeological materials between units (blue dots), units with archaeological materials (red squares) and units without archaeological materials (white squares). In grey, the grid of 25 hectares from which one hectare was selected.

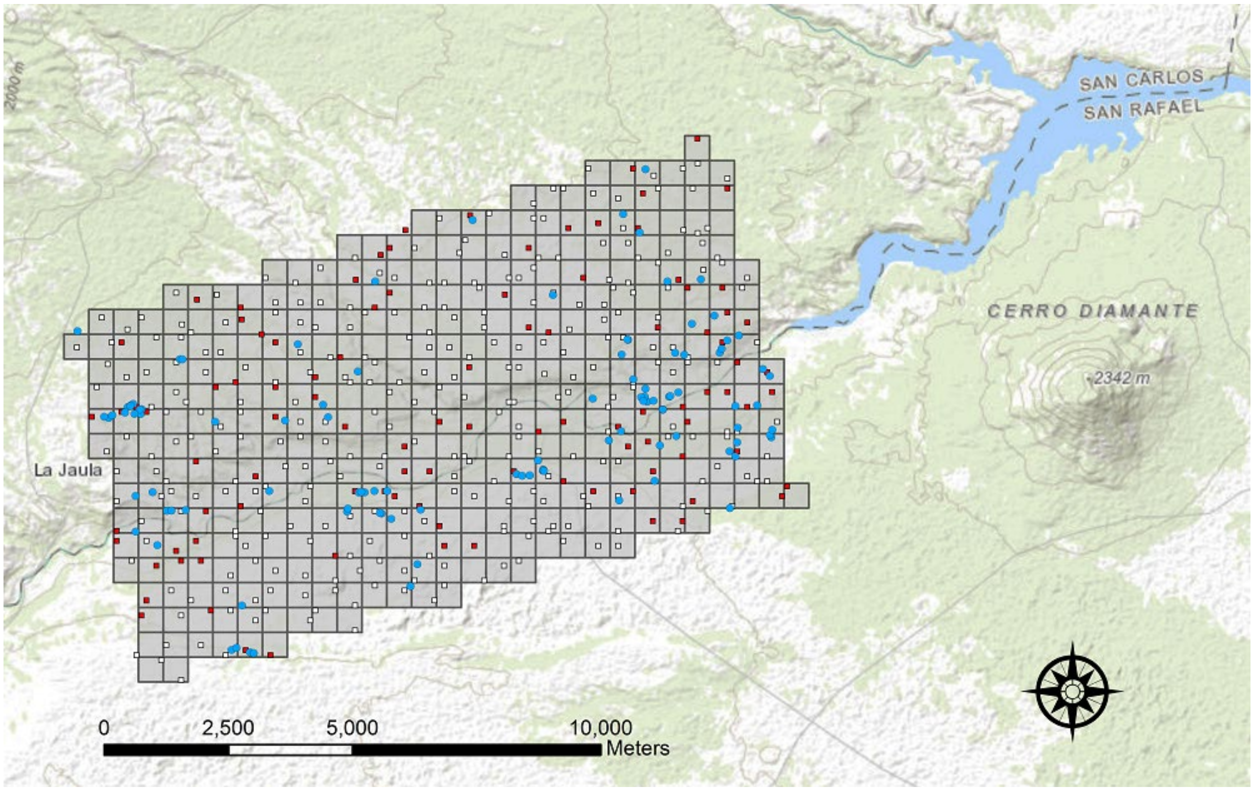

Figure 6.2 Map of the Piedmont showing locations with archaeological materials between units (blue dots), units with archaeological materials (red squares) and units without archaeological materials (white squares). In grey, the grid of 25 hectares from which one hectare was selected.

Artifact type, for the total sample in the Highlands, consist of 3.1% (N=103) tools, 1.2% (N=40) cores, and 95.7% (N=3163) debitage (Table 6.1). Raw materials, for the total sample in the Highlands, are comprised of 45.9% (N=1516) basalt, 41.1% (N=1360) cryptocrystalline, 12.4% (N=409) obsidian, and 0.6% (N=21) others (Table 6.2). The percentages of cortex, for the total sample in the Highlands, are 77.2% (N=2531) 0% cortex, 19.1% (N=633) 50% cortex, and 4.3% (N=142) 100% cortex (Table 6.3).

Table 6.1 Frequency and percentage of artifact type in the Highlands within units, between units, and the sum of all lithic materials.

Highlands						
Artifact type	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Tools	21	6.2	82	2.8	103	3.1
Cores	13	3.8	27	0.9	40	1.2
Debitage	306	90.0	2,857	96.3	3,163	95.7
Total	340	100.0	2,966	100.0	3,306	100.0

Table 6.2 Frequency and percentage of raw materials in the Highlands within units, between units, and the sum of all lithic materials.

Highlands						
Raw material	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Basalt	221	65.0	1,295	43.7	1,516	45.9
Cryptocrystalline	104	30.6	1256	42.3	1,360	41.1
Obsidian	15	4.4	394	13.3	409	12.4
Others	0	0.0	21	0.7	21	0.6
Total	340	100.0	2,966	100.0	3,306	100.0

Table 6.3 Frequency and percentage of cortex in the Highlands within units, between units, and the sum of all lithic materials.

Highlands						
Cortex percentages	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0 cortex	242	71.2	2,289	77.2	2,531	76.6
50 cortex	84	24.7	549	18.5	633	19.1
100 cortex	14	4.1	128	4.3	142	4.3
Total	340	100.0	2,966	100.0	3,306	100.0

Artifact types, for the total sample in the Piedmont, consist of 2.7% (N=63) tools, 4.3% (N=99) cores, and 93% (N=2147) debitage (Table 6.4). The raw materials, for the total sample in the Piedmont, are comprised of 71.6% (N=1653) basalt, 24% (N=554) cryptocrystalline, 2.4% (N=55) obsidian, and 2% (N=47) others (Table 6.5). The percentages of cortex, for the total sample in the Piedmont, are 62.4% (N=1140) 0% cortex, 22.4% (N=517) 50% cortex and 15.2% (N=352) 100% cortex (Table 6.6).

Table 6.4 Frequency and percentage of artifact type in the Piedmont within units, between units, and the sum of all lithic materials.

Piedmont						
Artifact type	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Tools	36	2.5	27	3.0	63	2.7
Cores	58	4.1	41	4.6	99	4.3
Debitage	1329	93.4	818	92.3	2147	93.0
Total	1423	100.0	886	100.0	2309	100.0

Table 6.5 Frequency and percentage of raw material in the Piedmont within units, between units, and the sum of all lithic materials.

Piedmont						
Raw material	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Basalt	1015	71.3	638	72.0	1653	71.6
Cryptocrystalline	349	24.5	205	23.1	554	24.0
Obsidian	27	1.9	28	3.2	55	2.4
Others	32	2.2	15	1.7	47	2.0
Total	1423	100.0	886	100.0	2309	100.0

Table 6.6 Frequency and percentage of artifact type in the Piedmont within units, between units, and the sum of all lithic materials.

Piedmont						
% cortex	Units		Between units		All	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0 cortex	868	61.0	572	64.6	1440	62.4
50 cortex	339	23.8	178	20.1	517	22.4
100 cortex	216	15.2	136	15.3	352	15.2
Total	1423	100.0	886	100.0	2309	100.0

6.2 **Archaeological sites**

Tables (6.7, 6.8) indicate the frequencies and percentages of findings grouped in ranges of N=1-3, N=4-24, and N> 25 in the units, between units and the sum of both for the Highlands and the Piedmont. This grouping permits identification, in a simple way, of the structure and variability of the surface materials in each ecological zone. It is important to clarify that the total number of N>25 in the Highlands is 11 because I grouped Unit 80 and Perdido 4, concomitantly the total of N>25 in the Piedmont is 13 because I grouped Unit 39, Rute 40 North and BU42. Beyond some slightly differences comparing the results within the units and between units, the percentages of the sum of each category are similar between ecological zones: 69.2% and 74.7% of the locations group in the N=1-3 category in the Highlands and the Piedmont respectively; 22.3% and 19% of the locations group in the N=4-24 category in the Highlands and the Piedmont respectively; and 8.4% and 6.3% group in the N>25 category in the Highlands and the Piedmont respectively. I add this information for two reasons, the first is to explore if overall the results from within units and between units were dramatically different using these grouping categories. I observe, looking at the frequencies, that in the Highlands the difference arose in the N=4-24 and N>25, while in the Piedmont that difference arose in the N=1-3 category. The second reason, is that in the literature of landscape archaeology of Patagonia, there is a tendency to report the structure of findings with these categories (Belardi 2005), but this approach is incomplete if we don't add an area to normalize the densities of materials (Drennan et al. 2015). Sometimes this information is reported from the range of visibility used in a transect, but very few times the area of a site is carefully delimited. To move forward to calculate an area density index I had to make contour line maps of the distribution of archaeological materials for the larger sites.

Table 6.7 Frequencies of sites, scatters of materials and isolated findings comparing units and between units in the Highlands.

Highlands						
	Units		Between units		All	
N grouping	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
N= 1-3	43	79.6	47	61.0	90	69.2
N= 4-24	7	13.0	22	28.6	29	22.3
N>25	4	7.4	8	10.4	11	8.4
Total	54	100.0	77	100.0	130	100.0

Table 6.8 Frequencies of sites, scatters of materials and isolated findings comparing units and between units in the Piedmont.

Piedmont						
	Units		Between units		All	
N grouping	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
N= 1-3	69	68.3	84	79.2	153	74.7
N= 4-24	21	20.8	18	17.0	39	19.0
N>25	11	10.9	4	3.8	13	6.3
Total	101	100.0	106	100.0	205	100.0

6.2.1 Contour lines maps of the distribution of archaeological materials for the larger sites in the Piedmont and the Highlands

There are five archaeological locations, that due to their sizes and densities, required a detailed analysis of their density and area: Perdido 1, Perdido 5, and Unit 80-Perdido 4 from the Highlands; Rute 40 South and Unit 39-Rute 40 North from the Piedmont (Figures 6.3-6.7). I decided to group Unit 80 and Perdido 4 as one site. The same criterion applied for Unit 39-Rute 40 North-BU42. With that decision I could move forward to calculate an area-density index. In contrast to the calculation of densities per area for the unit results, which were normalized by the equal size of one hectare per unit, for this calculation I considered the sum of counts divided by the square meters of each SCU ($100m^2$) to establish a density measure. Then, this value was multiplied by an area in hectares; for most of the small scatters, this value was 100 m^2 of the SCU in hectares (0.01), but for the larger sites the areas were derived from the contour maps.

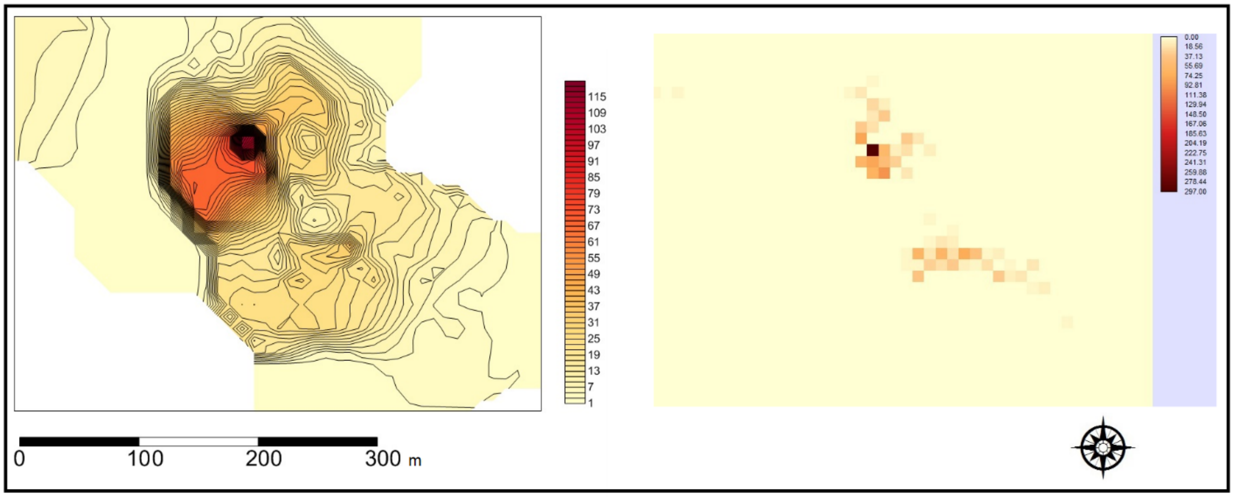

Figure 6.3 Contour line map of the distribution of archaeological materials for Perdido 1 (left) with materials densities, scale in meters. Cells of 10*10 meters with materials densities for Perdido 1 (right).

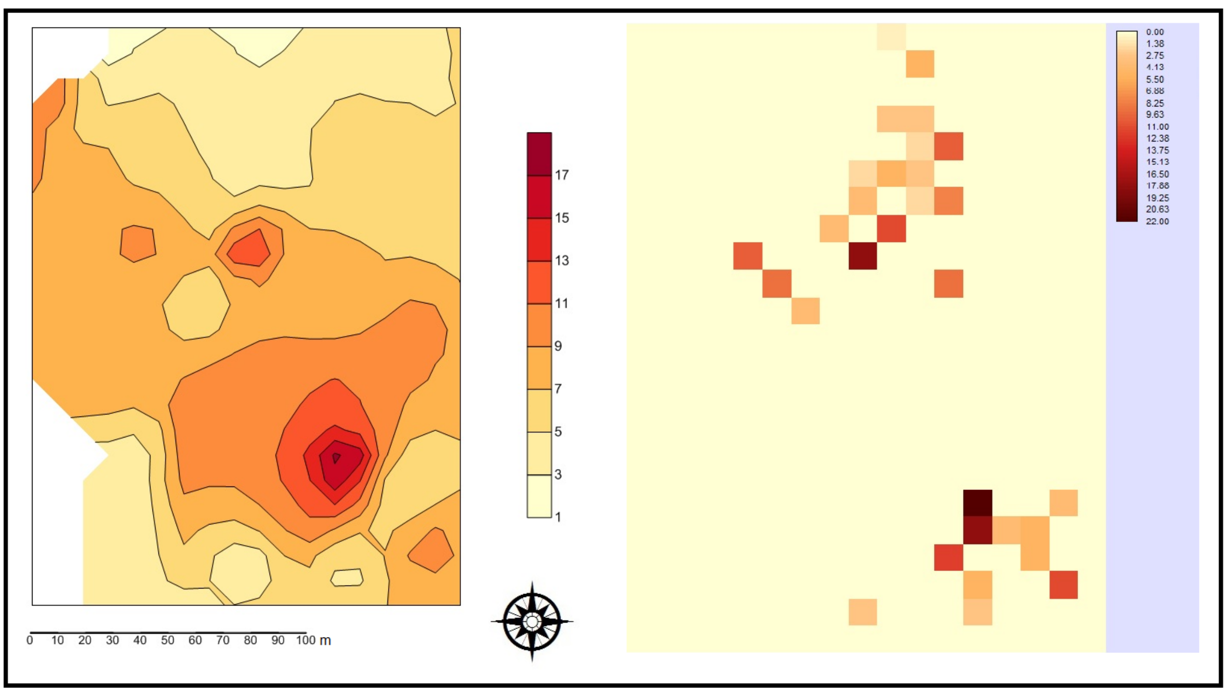

Figure 6.4 Contour line map of the distribution of archaeological materials for Unit 80- Perdido 4 (left) with materials densities, scale in meters. Cells of 10*10 meters with materials densities for Unit 80- Perdido 4 (right).

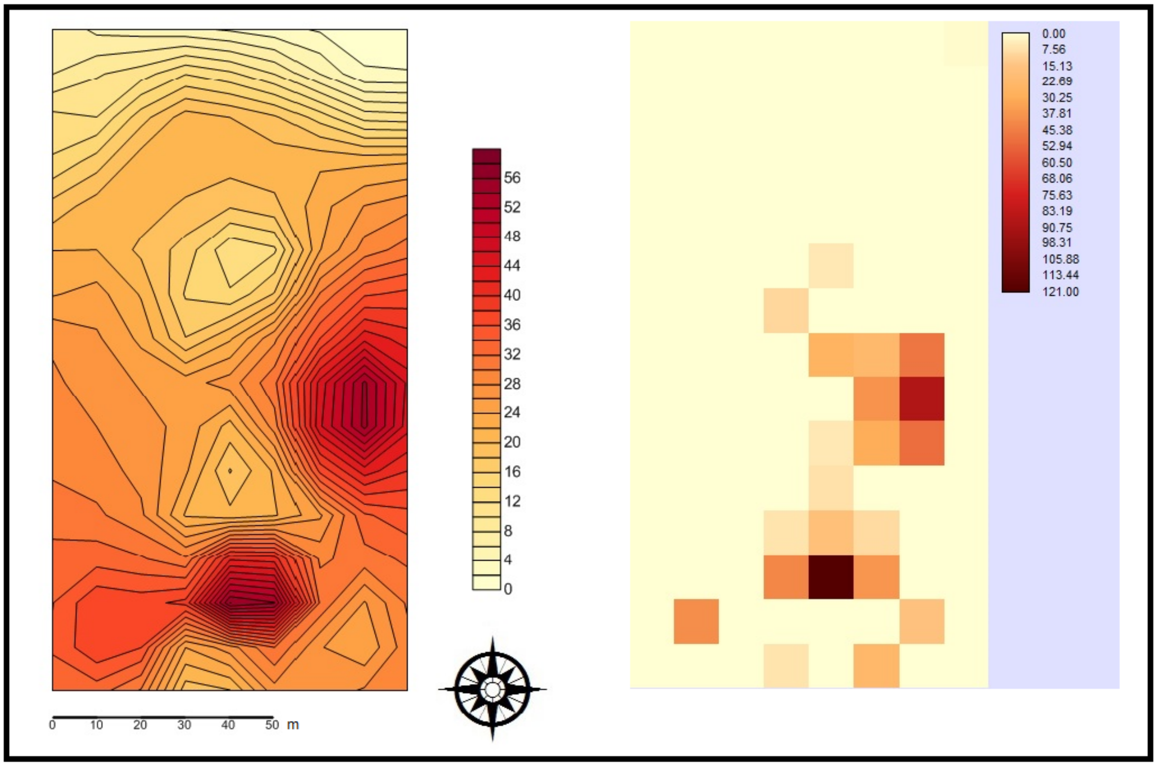

Figure 6.5 Contour line map of the distribution of archaeological materials for Perdido 5 (left) with materials densities, scale in meters. Cells of 10*10 meters with materials densities for Perdido 5 (right).

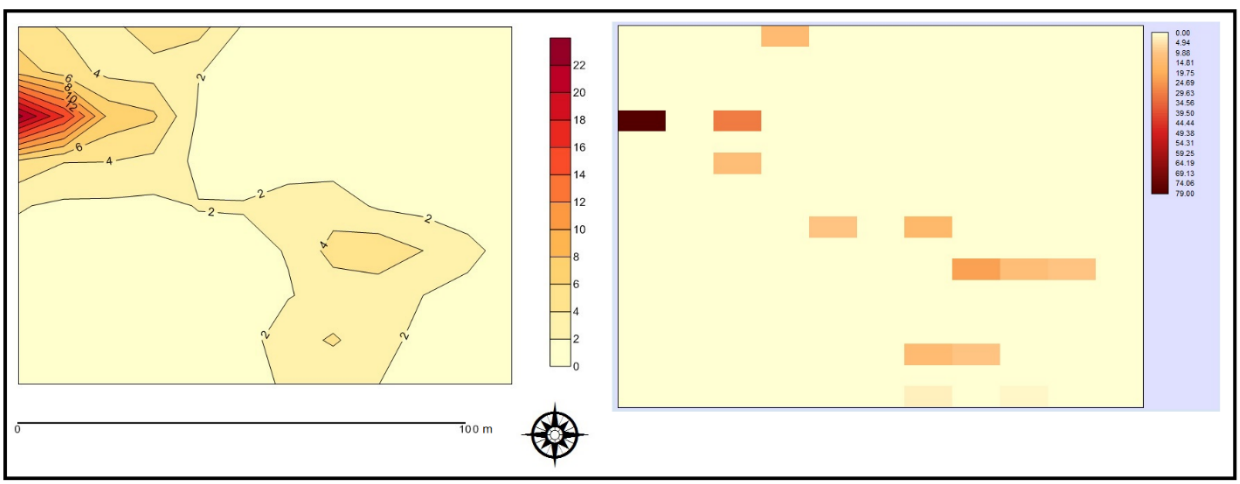

Figure 6.6 Contour line map of the distribution of archaeological materials for Rute 40 South (left) with materials densities, scale in meters. Cells of 10*10 meters with materials densities for Rute 40 South (right).

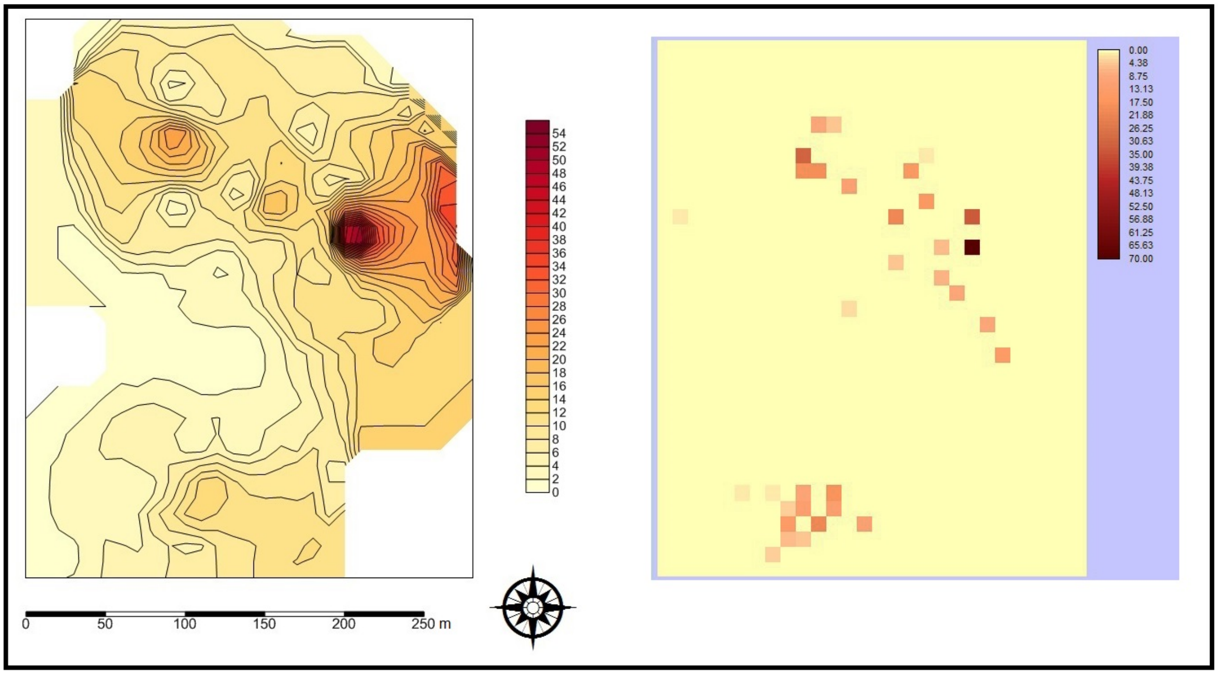

Figure 6.7 Contour line map of the distribution of archaeological materials for Unit 39-Rute 40 North (left) with materials densities, scale in meters. Cells of 10*10 meters with materials densities for Unit 39-Rute 40 North (right).

6.2.2 **Area-density index for all the data collected**

In this section I use all data, both those collected within units and those collected between units. To calculate the density area index with the counts of lithics and ceramics, first I divided the counts by the squared meters of every SCU in each unit or between unit to calculate the density. Then, I multiplied these values by the area in hectares. For the larger sites I calculated the area in hectares after addressing their size with contour lines maps of the distribution of archaeological materials.

To report the results of the density area index I generated two tables for each ecological zone, in tables (6.9, 6.11) the first column indicates the number of cases that the units or between units have with the same count. The following columns indicate squares meters of the SRU, density and area density index; while the last column "total" reports the sum of the area density index according to the number of cases. I condensed the data with the number of cases and the total sum to avoid a long table. For example, in the Highlands 56 locations had an area density of 0.0001, then, the total is 0.0056. In addition, tables (6.10, 6.12) reports the units or between units with unique values.

The sum of total density is 7.1 for the Highlands. The total sum for the area-density index in the Highlands is 1.615 considering units and between units. However, Perdido 1 with area density value of 1.04, represents almost two thirds of the density area of the Highlands. In Figure (6.8) are the locations in blue points that show proportionally their values for the area-density index. Most of these locations, and the larger ones, tend to cluster towards the Perdido stream in the Highlands.

Table 6.9 Area-density index for archaeological location in the Highlands which repeats its values.

N times with same case	Counts	Number of SRU	Squared meters of SRU	Density	Site Area in hectares	Area density index	Total
56	1	1	100	0.01	0.01	0.0001	0.0056
16	2	1	100	0.02	0.01	0.0002	0.0032
2	2	2	200	0.01	0.02	0.0002	0.0004
11	3	1	100	0.03	0.01	0.0003	0.0033
2	4	1	100	0.04	0.01	0.0008	0.0004
3	5	1	100	0.05	0.01	0.0015	0.0003
4	6	1	100	0.06	0.01	0.0024	0.0004
2	8	1	100	0.08	0.01	0.0008	0.0016
6	9	1	100	0.09	0.01	0.0009	0.0054
2	22	1	100	0.22	0.01	0.0022	0.0044
2	23	1	100	0.23	0.01	0.0023	0.0046
3	25	2	200	0.125	0.02	0.0025	0.0075

Table 6.10 Area-density index for archaeological location in the Highlands with unique values.

Unit - Between Unit	Counts	Number of SRU	Squared meters of SRU	Density	Site Area in hectares	Area density index
BU67	7	1	100	0.07	0.01	0.0007
BU66	10	1	100	0.1	0.01	0.0010
BU18	11	1	100	0.11	0.01	0.0011
BU23	16	1	100	0.16	0.01	0.0016
BU20	19	1	100	0.19	0.01	0.0019
BU62	28	1	100	0.28	0.01	0.0028
Unit 163	32	1	100	0.32	0.01	0.0032
Unit 10	35	1	100	0.35	0.01	0.0035
BU59	43	1	100	0.43	0.01	0.0043
BU16	56	1	100	0.56	0.01	0.0056
Perdido 1	1805	78	7800	0.231	4.5	1.0413
Perdido 5	746	23	2300	0.324	1.1	0.3568
80 - Perdido 4	208	31	3100	0.067	2.3	0.1543

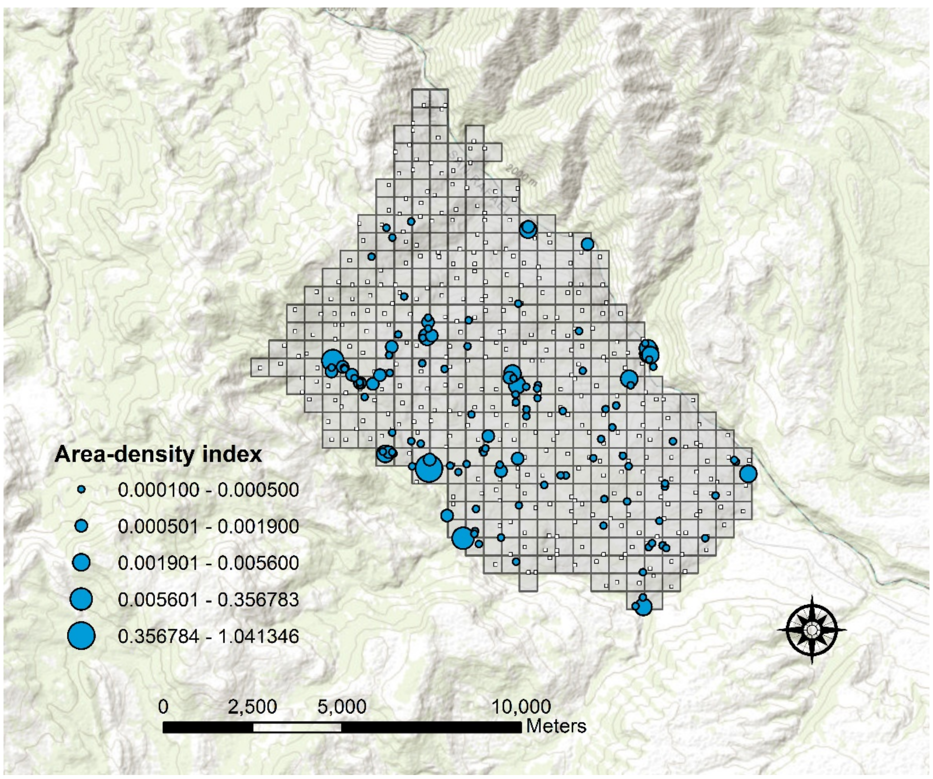

Figure 6.8 Area-density index for all archaeological locations in the Highlands, the points indicate their proportional size according to their index value, they are the sum of locations that correspond both to units and between units; for reference, a grey grid represents the 25 hectares from which a unit was selected.

The sum of total density is 7.87 for the Piedmont. The total sum for the area-density index in the Piedmont is 0.498 considering units and between units. In Figure (6.9) are the locations in blue points that show proportionally their values for the area-density index. Most of these locations, and the larger ones, tend to cluster towards the east in the Piedmont; some other locations also spread across the Diamante river.

Table 6.11 Area-density index for archaeological location in the Piedmont which repeats its values.

N times with same case	Counts	Number of SCU	Squared meters of SCU	Density	Site Area in hectares	Area density index	Total
105	1	1	100	0.01	0.01	0.0001	0.0105
34	2	1	100	0.02	0.01	0.0002	0.0068
4	2	2	200	0.01	0.02	0.0002	0.0008
10	3	1	100	0.03	0.01	0.0003	0.0030
5	4	1	100	0.04	0.01	0.0004	0.0020
3	4	2	200	0.02	0.02	0.0004	0.0012
3	5	1	100	0.05	0.01	0.0005	0.0015
3	6	1	100	0.06	0.01	0.0006	0.0018
4	7	1	100	0.07	0.01	0.0007	0.0028
2	8	1	100	0.08	0.01	0.0008	0.0016
4	9	1	100	0.09	0.01	0.0009	0.0036
2	11	1	100	0.11	0.01	0.0011	0.0022
2	12	1	100	0.12	0.01	0.0012	0.0024
2	14	1	100	0.14	0.01	0.0014	0.0028

Table 6.12 Area-density index for archaeological location in the Piedmont with unique values.

Unit - Between Unit	Counts	Number of SCU	Squared meters of SCU	Density	Site Area in hectares	Area density index
263	5	2	200	0.0250	0.02	0.00050
26	7	2	200	0.0350	0.02	0.00070
161	9	3	300	0.0300	0.03	0.00090
390	9	2	200	0.0450	0.02	0.00090
317	11	2	200	0.0550	0.02	0.00110
369	13	2	200	0.0650	0.02	0.00130
309	16	3	300	0.0533	0.03	0.00160
BU80	19	1	100	0.1900	0.01	0.00190

266	21	2	200	0.1050	0.02	0.00210
389	25	2	200	0.1250	0.02	0.00250
265	33	3	300	0.1100	0.03	0.00330
264	46	4	400	0.1150	0.04	0.00460
380	49	3	300	0.1633	0.03	0.00490
372	50	3	300	0.1667	0.03	0.00500
388	51	3	300	0.1700	0.03	0.00510
320	53	4	400	0.1325	0.04	0.00530
BU65	64	5	500	0.1280	0.05	0.00640
201	65	1	100	0.6500	0.01	0.00650
105	71	2	200	0.3550	0.02	0.00710
Rute 40 South	259	16	1600	0.1619	0.45	0.07284
Unit 39-Rute 40 North	459	52	5200	0.0883	3	0.26481
115	564	8	800	0.7050	0.08	0.05640

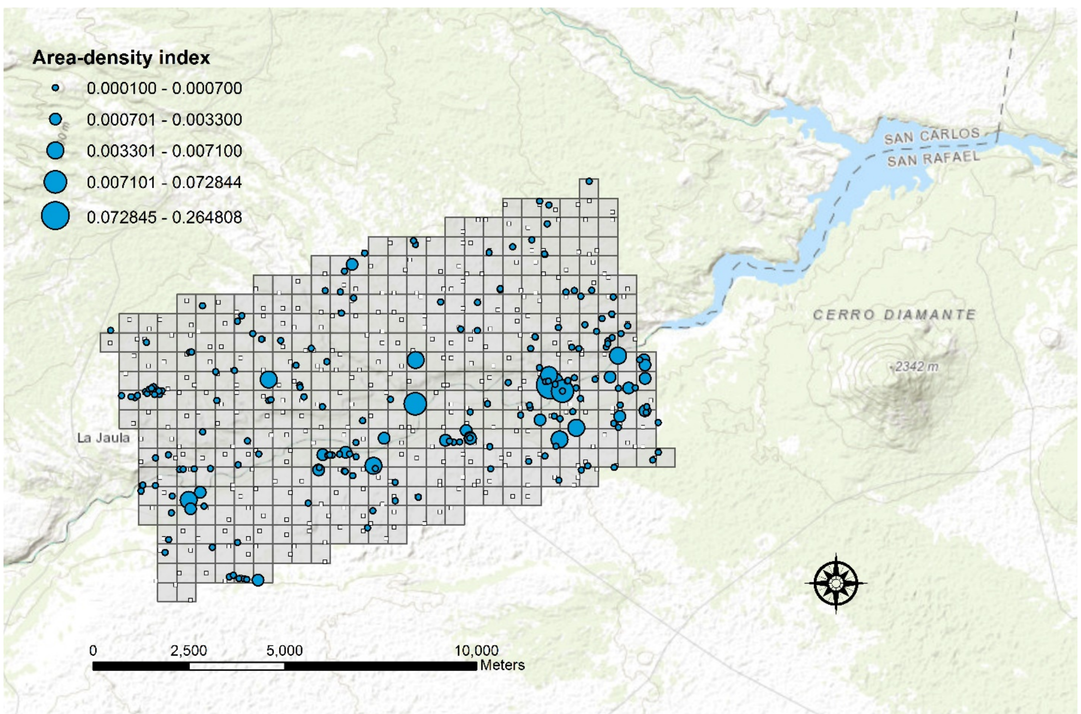

Figure 6.9 Area-density index for all archaeological locations in the Piedmont, the points indicate their proportional size according to their index value, they are the sum of locations that correspond both to units and between units; for reference, a grey grid represents the 25 hectares from which a unit was selected.

6.3 **Lithics for sites with N > 25**

In the Piedmont, tools are predominant in the sites Rute 40 South, 39-Rute 40 North, and Unit 115. In contrast, cores present a higher percentage in Unit 105, Unit 388 and BU65 sites; consequently, these locations have a lower percentage of debitage, below 85% in the three cases (Table 6.13). The sites with higher proportion of cores are located towards the east of the surveyed area (Figure 6.10). In the Highlands, tools are predominant in the sites Perdido 1, Perdido 5, BU16, Unit 10, Unit 186 and Unit 163. In contrast, cores present a higher percentage in BU71; however, the largest frequency is present in Perdido 1 (N=16). Most of the sites, except for Unit 163, have a debitage percentage above 90% (Table 6.14, Figure 6.11).

Table 6.13 Frequency and percentage of artifact type per site in the Piedmont.

Piedmont							
Site	Tools		Cores		Debitage		Total
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
39-Rute 40 North	**11**	**2.4**	6	1.3	440	96.3	457
Unit 105	1	1.4	**23**	**32.4**	**47**	**66.2**	71
Unit 115	**13**	**2.3**	1	0.2	550	97.5	564
Unit 201	1	1.6	1	1.6	62	96.9	64
Unit 264		0.0	1	2.2	45	97.8	46
Unit 265	1	3.0		0.0	32	97.0	33
Unit 320		0.0		0.0	53	100.0	53
Unit 372	**3**	**6.0**	2	4.0	45	90.0	50
Unit 380	1	2.0		0.0	48	98.0	49
Unit 388	1	2.0	**7**	**13.7**	**43**	**84.3**	51
Unit 389	**2**	**8.0**		0.0	23	92.0	25
BU65		0.0	**19**	**29.7**	**45**	**70.3**	64
Rute 40 South	**6**	**2.5**	1	0.4	234	97.1	241
Total	40	2.3	61	3.5	1667	94.3	1768

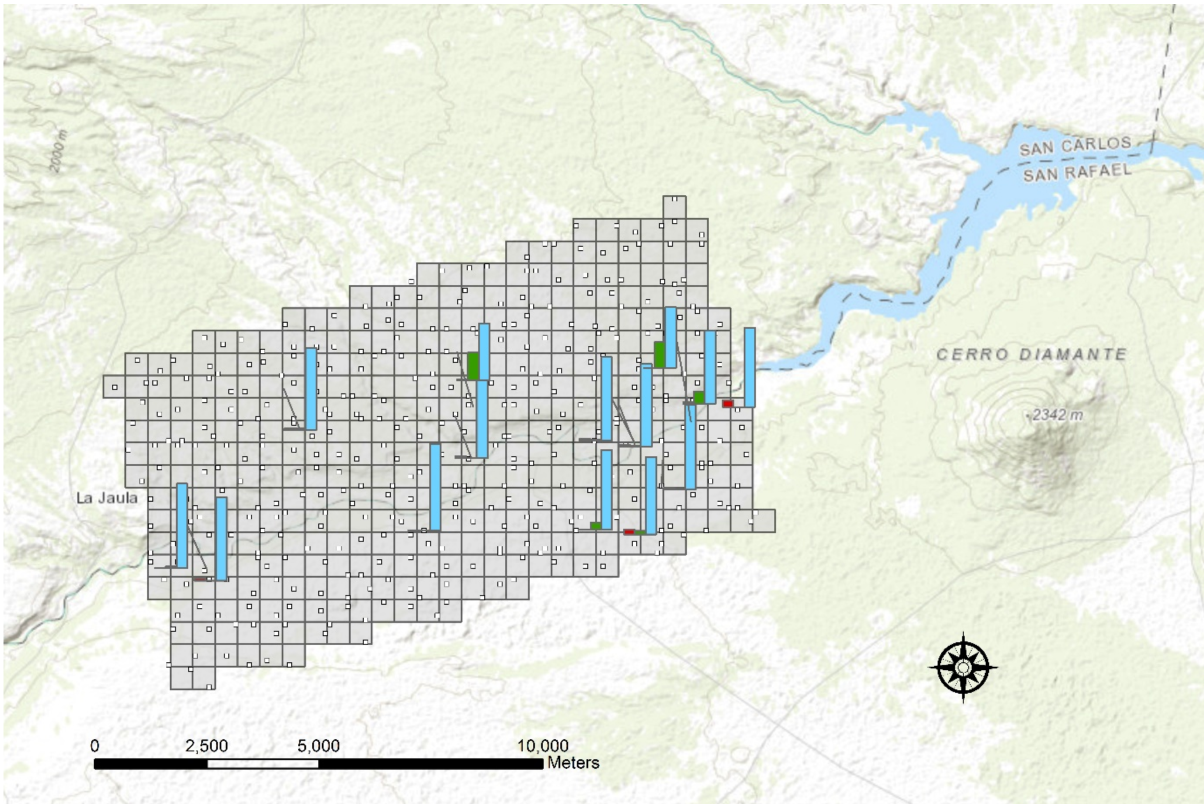

Figure 6.10 Percentage of artifact type, debitage (light blue), tools (red) and cores (green), per site N>25 in the Piedmont.

Table 6.14 Frequency and percentage of artifact type in the Highlands.

Highlands							
Site	Tools		Cores		Debitage		Total
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Unit 10	**3**	**8.6**		0.0	32	91.4	35
80-Perdido 4	3	1.5	1	0.5	195	98.0	199
Unit 163	**3**	**9.4**	1	3.1	**28**	**87.5**	32
Unit 186	**1**	**4.0**		0.0	24	96.0	25
Perdido 5	**18**	**2.9**	3	0.5	605	96.6	626
BU16	**3**	**5.4**		0.0	53	94.6	56
BU50		0.0		0.0	25	100.0	25
BU59	1	2.3	1	2.3	41	95.3	43
BU62	1	3.6		0.0	27	96.4	28
BU71		0.0	**2**	**8.0**	23	92.0	25
Perdido 1	**39**	**2.2**	16	0.9	1750	97.0	1805
Total	68	2.4	24	0.8	2784	96.8	2877

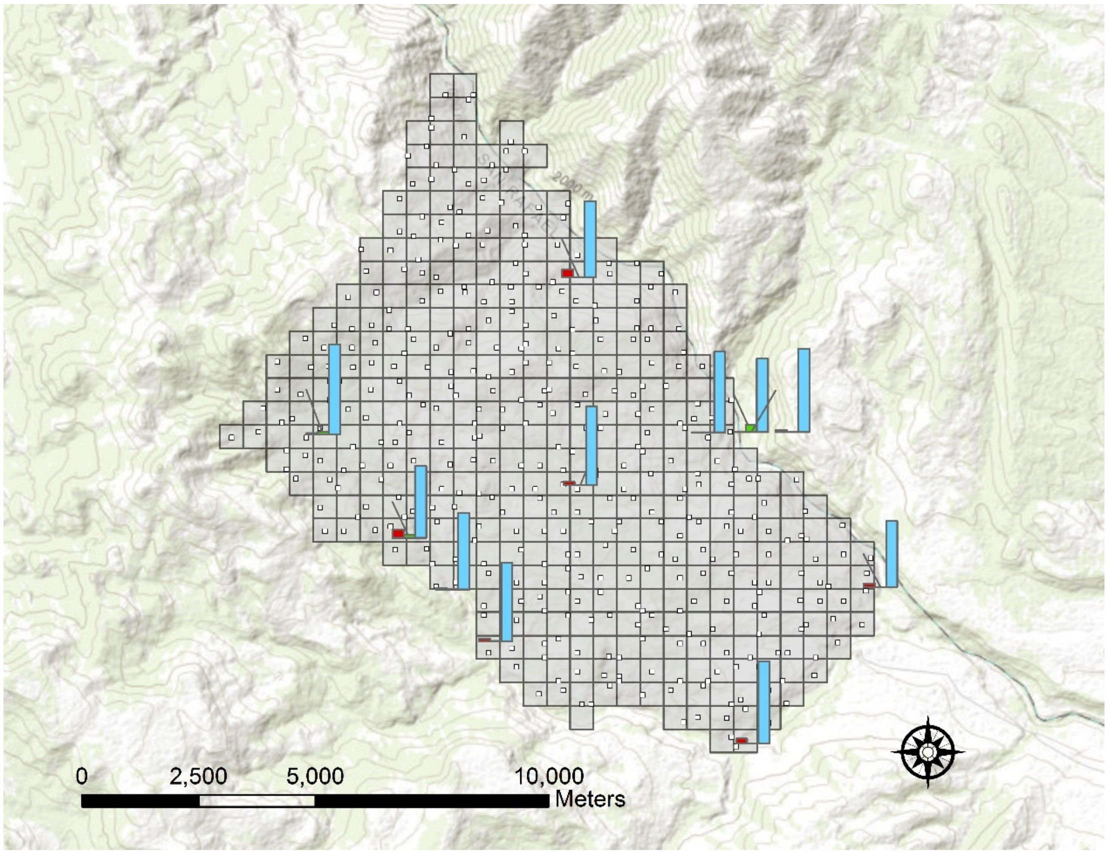

Figure 6.11 Percentage of artifact type, debitage (light blue), tools (red) and cores (green), per site N>25 in the Highlands.

In the Piedmont the frequencies and percentages for raw materials, indicate a predominance of basalts across all the sites and a different importance of cryptocrystalline and obsidian in a few sites (Table 6.15). This pattern is consistent with the different index values as well (Table 6.16). The sites Unit 39-Rute 40 North, Unit 320, Unit 372 and Unit 380 have higher ratios for basalt with values that range between 8 and 24. The sites Unit 105 and BU65 have higher ratios for cryptocrystalline with a value of 70 and 15 respectively. The sites Unit 115 and Rute 40 South have higher ratios for obsidian with a value of 0.037 and 0.048 respectively (Table 6.16). The sites with a prevalence of basalts locate towards the east and across the course of the Diamante river; a few other sites indicate a higher proportion of cryptocrystalline slightly further from the water courses (Figure 6.12)

In the Highlands contrast the higher proportions of obsidian in sites Unit 80-Perdido 4, Unit 163, Perdido 5 and Perdido 1 that range from 9-26 %. It is also remarkable the proportions of cryptocrystalline in these sites that range from 20-45% (Table 6.17). The indexes for these raw materials, and specifically for obsidian, confirm this observation (Table 6.18). This trend towards a more balanced composition among raw materials, is present mostly in sites next to the Perdido stream and the center of the surveyed area (Figure 6.13). The sites Perdido 1, BU62, Perdido 5, Unit 80-Perdido 4 and Unit 163 present a ratio for obsidian that is higher than 0.1, in considerable contrast to the values of higher ratios for obsidian in sites of the Piedmont (Tables 6.18, 6.16).

Table 6.15 Frequency and percentage of raw material per site in the Piedmont.

Piedmont									
	Basalt		Cryptocristallyne		Obsidian		Others		
Site	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Total
39-Rute 40 North	407	89.0	42	9.1	6	**1.3**	2	0.6	457
Unit 105	1	1.4	**70**	**98.6**		0.0		0.0	71
Unit 115	402	71.3	141	25.0	**20**	**3.5**	1	0.2	564
Unit 201		0.0	**64**	**100.0**		0.0		0.0	64
Unit 264	46	100.0		0.0		0.0		0.0	46
Unit 265	33	100.0		0.0		0.0		0.0	33
Unit 320	50	94.3	1	1.9	1	**1.9**	1	1.9	53
Unit 372	47	94.0	2	4.0	1	2.0		0.0	50
Unit 380	47	95.9	2	4.1		0.0		0.0	49
Unit 388	51	100.0		0.0		0.0		0.0	51
Unit 389	25	100.0		0.0		0.0		0.0	25
BU65	3	4.7	**60**	**93.8**	1	**1.6**		0.0	64
Rute 40 South	143	59.3	**81**	**33.6**	**11**	**4.6**	6	2.5	241
Total	1255	71.0	463	26.2	40	**2.3**	10	0.6	1768

Table 6.16 Basalt, cryptocrystalline, obsidian and others raw materials indexes per sites in the Piedmont.

Index of raw material per site Piedmont				
Site	Basalt	Cryptocrystalline	Obsidian	Others
39 Rute 40 North	**8.140**	0.101	0.013	0.004
Unit 105	0.014	**70.000**	0.000	0.000
Unit 115	2.481	0.333	**0.037**	0.002

Unit 320	**16.667**	0.019	0.019	0.019
Unit 372	**15.667**	0.042	0.020	0.000
Unit 380	**23.500**	0.043	0.000	0.000
BU65	0.049	**15.000**	0.016	0.000
Rute 40 South	1.459	0.506	**0.048**	0.026

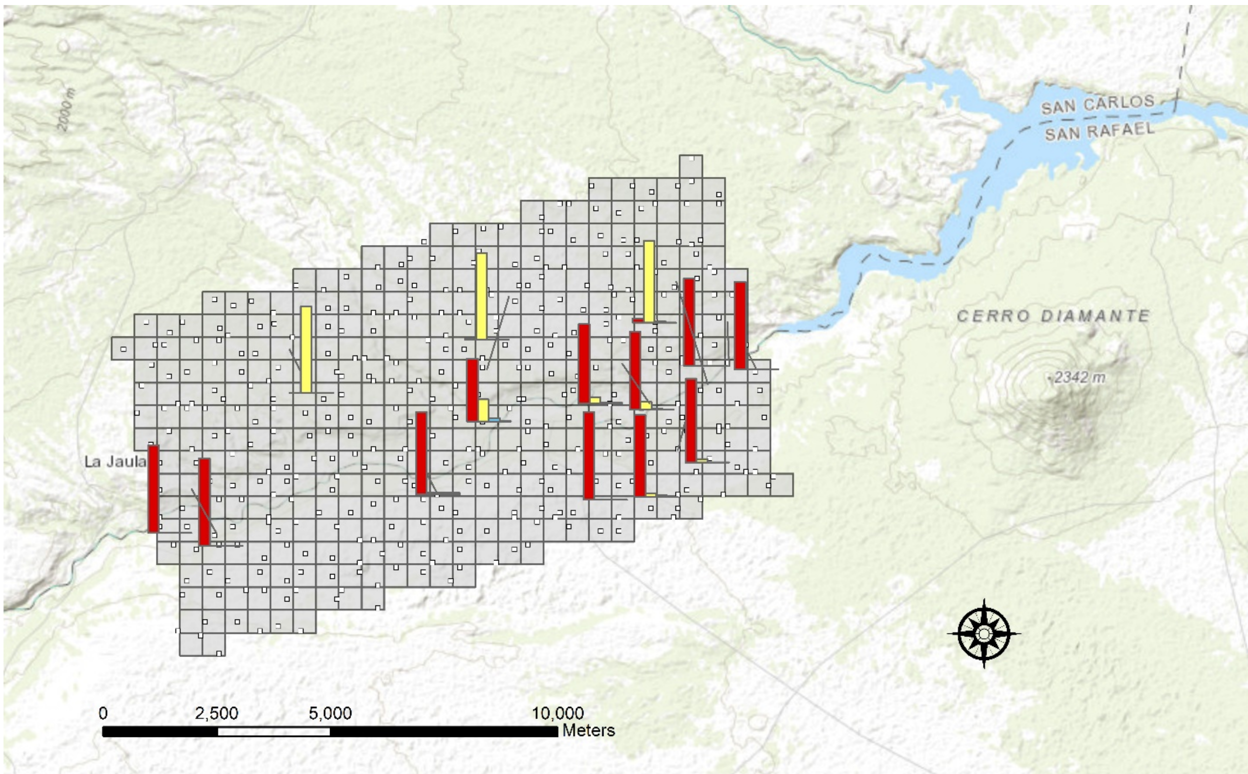

Figure 6.12 Raw material per site N>25 in the Piedmont. Basalt (red), cryptocrystalline (yellow), and obsidian (light blue).

Table 6.17 Frequency and percentage of raw material per site in the Highlands.

Highlands									
	Basalt		Cryptocrystalline		Obsidian		Others		
Site	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Total
Unit 10	29	82.9	3	8.6	3	**8.6**		0.0	35
80-Perdido 4	115	57.8	61	30.7	21	**10.6**	2	1.0	199
Unit 163	22	68.8	7	21.9	3	**9.4**		0.0	32
Unit 186	25	100.0		0.0		0.0		0.0	25
Perdido 5	166	26.5	290	46.3	167	**26.7**	3	0.5	626

BU16	50	89.3	4	7.1	2	3.6		0.0	56
BU50	20	80.0	3	12.0	2	8.0		0.0	25
BU59	43	100.0		0.0		0.0		0.0	43
BU62	18	64.3	7	25.0	3	10.7		0.0	28
BU71	25	100.0		0.0		0.0		0.0	25
Perdido 1	793	43.9	808	44.8	192	**10.6**	12	0.7	1805
Total	1295	45.0	1175	40.8	390	13.6	17	0.6	2877

Table 6.18 Basalt, cryptocrystalline, obsidian and other raw materials indexes per site in the Highlands.

Index of raw material per site in the Highlands				
Site	Basalt	Cryptocrystalline	Obsidian	Others
Unit 10	4.833	0.094	0.094	0.000
80 - Perdido 4	1.369	0.442	**0.118**	0.010
Unit 163	2.200	0.280	**0.103**	0.000
Perdido 5	0.361	0.863	**0.364**	0.005
BU16	8.333	0.077	0.037	0.000
BU50	4.000	0.136	0.087	0.000
BU62	1.800	0.333	**0.120**	0.000
Perdido 1	0.784	0.810	**0.119**	0.007

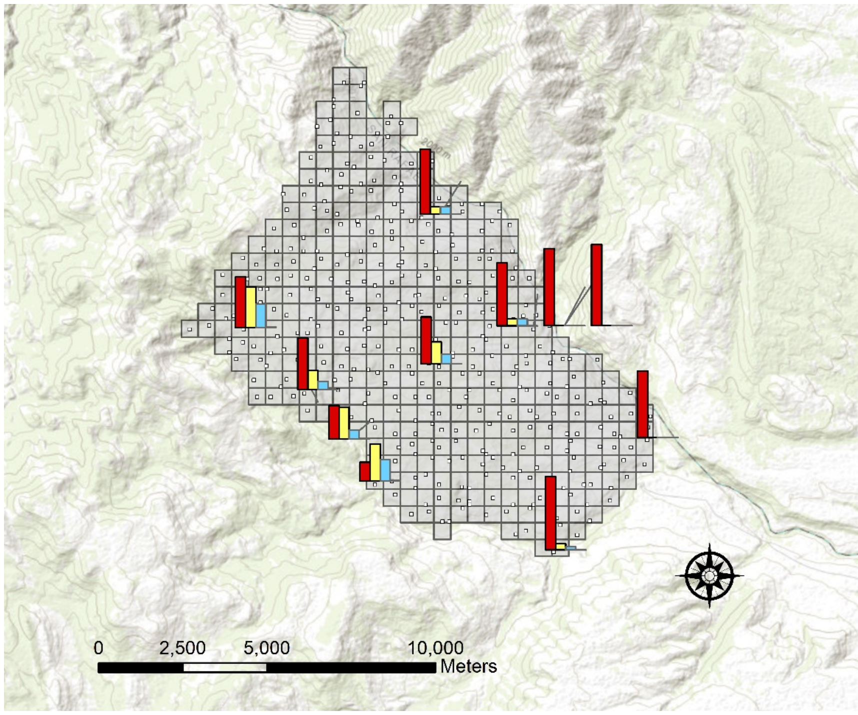

Figure 6.13 Raw material per site N>25 in the Highlands. Basalt (red), cryptocrystalline (yellow), and obsidian (light blue).

The percentage of cortex refers exclusively to the amount of cortex that covers the dorsal face of a piece. Therefore, in a piece with 100% of cortex, the internal face indicates that a primary flake has been detached, 50% of cortex implies that the half of the dorsal face is covered with cortex. In the Piedmont, a group of sites have higher percentages, which range between 35-55%, of the pieces of chipped stone half covered in cortex: Units 105, 201, 264, 265, and 372; in addition, BU65, units 105 and 201 have higher percentages of 100% cortex (Table 6.19). These last locations are mostly composed of cryptocrystalline materials (Table 6.15) and situated slightly away from the water sources (Figures 6.12, 6.14). The rest of locations with different degrees of cortex percentage are mainly associated with basalts, suggesting that this raw material was acquired from the eastern section of the survey area and from some secondary sources located across the Diamante river.

In the Highlands, few locations, mainly BU59 and BU71, have 100% of cortex which are located in the center of the surveyed area, next to the Diamante river and associated with basalt (Figures 6.15, 6.13, Table 6.20). The sites close to the Perdido stream present 20% of the pieces of chipped stone half covered in cortex (Figures 6.15, 6.13).

Table 6.19 Frequency and percentage of cortex % per site in the Piedmont.

Piedmont							
	0% cortex		50% cortex		100% cortex		
Site	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Total
39-Rute 40 North	362	79.2	59	12.9	36	7.8	457
Unit 105	13	18.3	**38**	**53.5**	**20**	**28.2**	71
Unit 115	426	75.5	99	17.6	39	6.9	564
Unit 201	13	20.3	**36**	**56.3**	**15**	**23.4**	64
Unit 264	18	39.1	**19**	**41.3**	9	19.6	46
Unit 265	18	54.5	**12**	**36.4**	3	9.1	33
Unit 320	39	73.6	5	9.4	9	17.0	53
Unit 372	21	42.0	**21**	**42.0**	8	16.0	50
Unit 380	31	63.3	13	26.5	5	10.2	49
Unit 388	32	62.7	9	17.6	10	19.6	51
Unit 389	17	68.0	3	12.0	5	20.0	25
BU65	9	14.1	24	37.5	**31**	**48.4**	64
Rute 40 South	158	65.6	48	19.9	34	14.1	241
Total	1157	65.4	386	21.8	224	12.7	1768

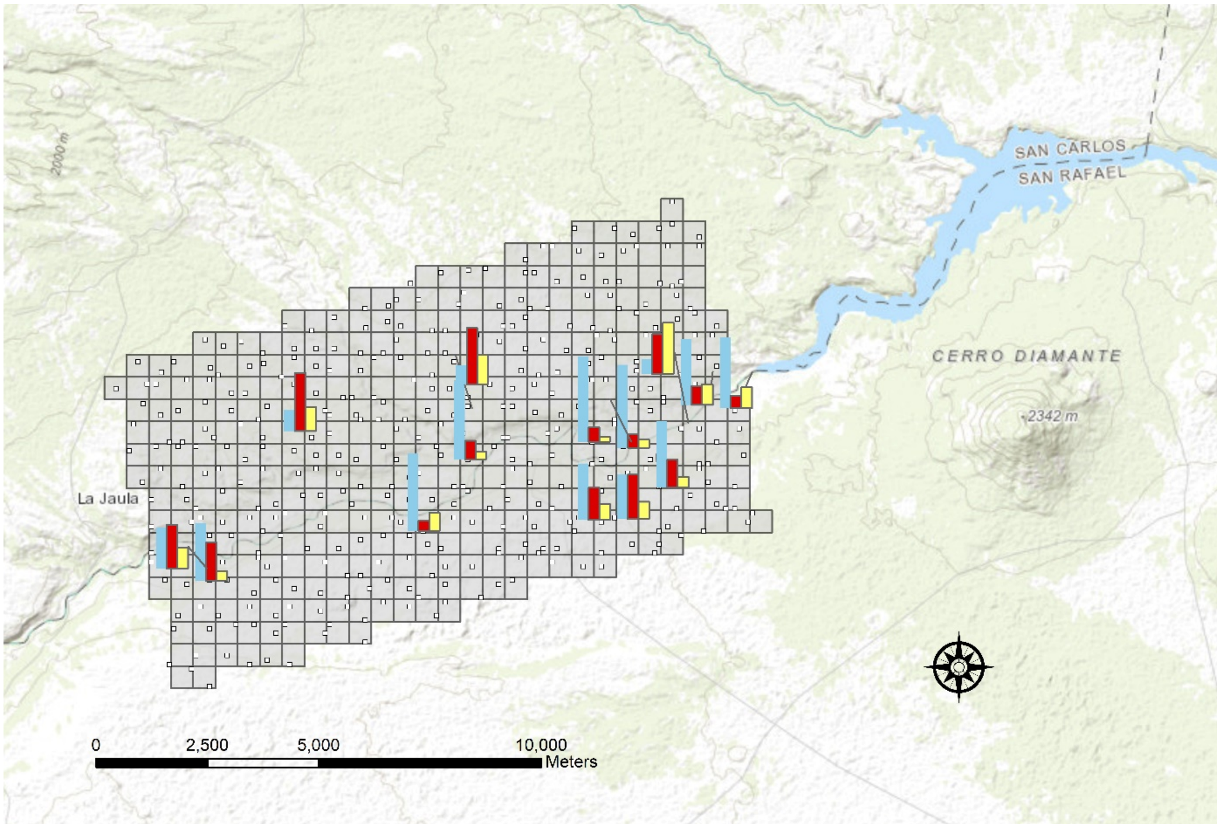

Figure 6.14 Percentage of cortex % per site in the Piedmont. 0% cortex (light blue), 50% cortex (red), and 100% cortex (yellow).

Table 6.20 Frequency and percentage of cortex % per site in the Highlands.

Highlands							
	0% cortex		50% cortex		100% cortex		
Site	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Total
Unit 10	31	88.6	3	8.6	1	2.9	35
80-Perdido 4	155	77.9	**34**	**17.1**	10	5.0	199
Unit 163	28	87.5	3	9.4	1	3.1	32
Unit 186	23	92.0	1	4.0	1	4.0	25
Perdido 5	489	78.1	102	**16.3**	35	5.6	626
BU16	45	80.4	9	**16.1**	2	3.6	56
BU50	23	92.0	1	4.0	1	4.0	25
BU59	21	48.8	**17**	**39.5**	**5**	**11.6**	43
BU62	20	71.4	**8**	**28.6**		0.0	28
BU71	9	36.0	**5**	**20.0**	**11**	**44.0**	25
Perdido 1	1448	80.2	315	**17.5**	42	2.3	1805
Total	2275	79.1	494	17.2	108	3.8	2877

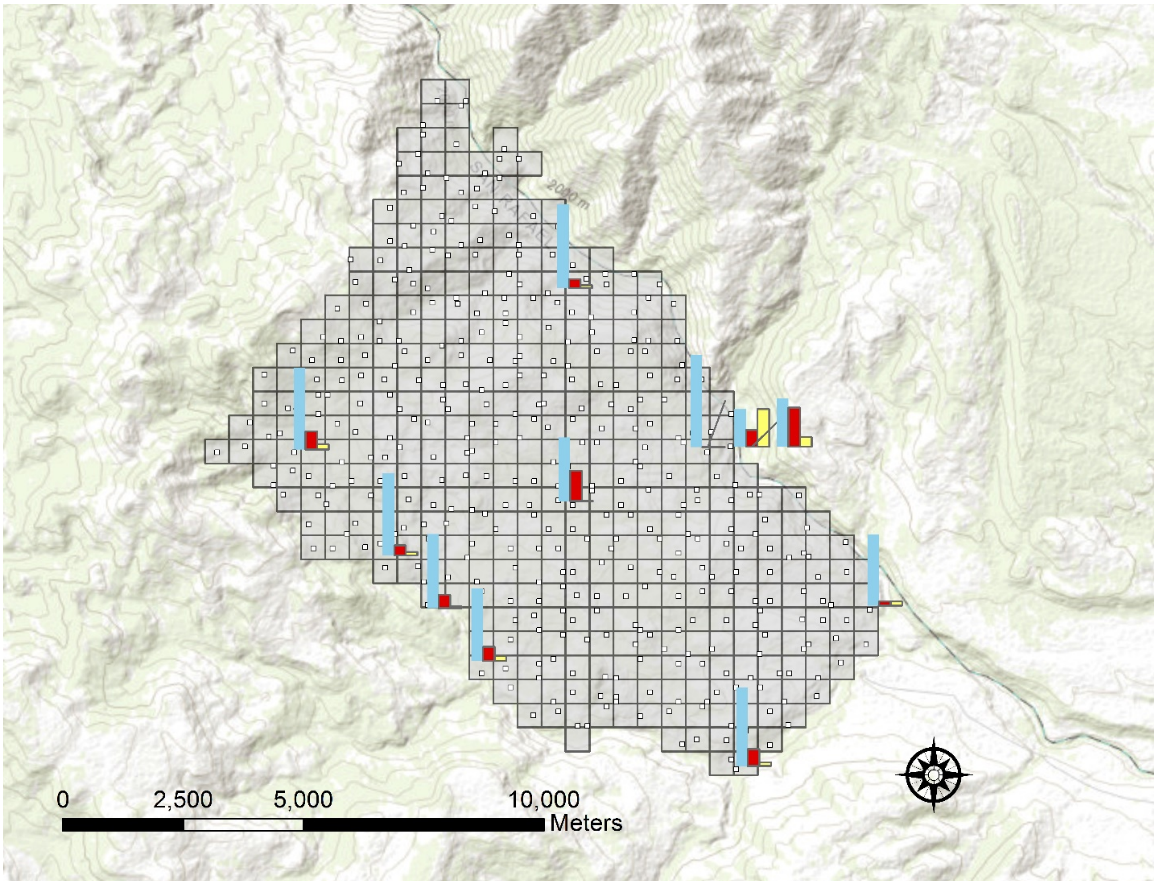

Figure 6.15 Percentage of cortex % per site in the Highlands. 0% cortex (light blue), 50% cortex (red), and 100% cortex (yellow).

6.4 **Persistent places: measures in the intensity of raw material utilization**

There are spots in the landscape that, due to their natural resources or the importance for social aggregation and activities, tend to be occupied repeatedly through time, and have been called "persistent places" (Shiner 2009). The distribution and importance of these locations can help us to infer in some degree, the level of sedentarism associated with them and therefore explore how people used mobility within the subsistence system. On a basic level, I assume that the higher the importance and presence of these persistent places, the lower would be the degree of mobility. I compare different ratios as proxies of the intensity use in raw materials to interpret in which degree some sites were persistent places.

6.4.1 **Local-non::local debitage, local debitage::non-local tools.**

Surovell (2012) argues that as people stay longer in any given place, local raw materials will increasingly dominate the lithic assemblage. However, the ratio of local::non-local debitage, not only depends on time. It can also depend on the size and state of the toolkit at the arrival moment, and the mean use-life of artifacts. Nevertheless, even having into account these factors, the premise of the ratio is still valid, and the longer an occupation is, more local raw materials will be exploited. In both the Highlands and the Piedmont, the only non-local raw material is obsidian. In addition, a complementary ratio that follows the same logic is local debitage::non-local tools. If we assume that a band or hunter will arrive to a location with tools made from non-local raw materials, the longer is the stay at place, the higher would be the values indicating more use of local raw materials as evidenced by local debitage (Surovell 2012).

The ratios for the Piedmont are considerably higher than in the Highlands. In the Piedmont, larger sites indicate a clear pattern of persistent occupation: Unit 39-Rute 40 North (90.2), Unit 115 (30.2), and Rute 40 South (20.9) (Table 6.21). In the larger sites from the Highlands, the sites Perdido 1 and Unit 80-Perdido 4 have similar values (8.5, 8.6) in contrast to Perdido 5 (2.9), indicating longer stays and therefore more persistent use of the localities in the former two. The rest of the sites actually have higher values than the larger sites (Table 6.22).

Table 6.21 Ratios local::non-local debitage for sites in the Piedmont.

Piedmont	Local debitage	Non local debitage	Ratio
39 Rute 40 North	451	5	90.2
Unit 115	544	18	30.2
Unit 320	52	1	52.0
BU65	63	1	63.0
Rute 40 South	230	11	20.9

Table 6.22 Ratios local::non-local debitage for sites in the Highlands.

Highlands	Local debitage	Non local debitage	Ratio
Unit 10	32	2	16.0
Unit 163	29	1	29.0
Perdido 5	459	157	2.9
BU16	54	2	27.0
BU50	23	2	11.5
BU62	25	3	8.3
80 - Perdido 4	178	21	8.5
Perdido1	1613	187	8.6

For the ratio of local debitage::non-local tools, the sites Unit 39 - Rute 40 North and Unit 115 from the Piedmont indicate high values and therefore a longer stay at these locations. In the Highlands, the site Perdido 1 has 9 times larger values than the sites Perdido 5, Unit 163 and Unit 10. For both ratios, the values are consistent indicating persistent occupation in the same sites.

Table 6.23 Local debitage::Non-local tools for sites in the Highlands.

Highlands	Local Debitage	Non-Local tools	Ratio
Unit 10	32	1	32
Unit 163	29	2	14.5
Perdido 5	456	10	45.6
Perdido 1	1601	5	320.2

Table 6.24 Local debitage::Non-local tools for sites in the Piedmont.

Piedmont	Local Debitage	Non-Local tools	Ratio
Unit 39 - Rute 40 North	449	1	449
Unit 115	544	2	272

6.4.2 **Minimum number of flakes (MNF) to core ratio**

The minimum number of flakes (MNF) to core ratio is a straightforward measure of core reduction intensity. The MNF involves the sum of the total number of flakes with platform, both entire or proximal, together with the longitudinal splits (Hiscock 2002). As core reduction advances, the number of flakes produced increases in relation to the number of cores (Andrefsky 2009). Therefore, longer occupations by less mobile groups will constrain the restock of new raw materials, resulting in a higher stage of core reduction. The main pattern observed is an opposite relation between cryptocrystalline and basalt use intensity between the Piedmont and the Highlands. The ratio for cryptocrystalline indicates much higher values in the Highlands than in the Piedmont (Tables 6.25, 6.27). While the ratio for basalt indicates some variability in the intensity of use in the Piedmont (Tables 6.26, 6.28). In both ecological zones, the lower ratios correlate with smaller sites, N ranging between 25-50, suggesting that these locations may be associated with either the first stages of reduction or raw material acquisition. Overall the ratio is consistent, with higher ratio values in the larger sites where we could expect longer stays.

Table 6.25 Minimum number of flakes (MNF) to core ratio in cryptocrystalline in sites from the Highlands.

Cryptocrystalline	MNF	Cores	Ratio
Unit 163	5	1	5.0
Perdido 1	751	16	**46.9**
Unit 80-Perdido 4	58	1	**58.0**
Perdido 5	274	2	**137.0**

Table 6.26 Minimum number of flakes (MNF) to core ratio in basalt in sites from the Highlands.

Basalt	MNF	Cores	Ratio
BU59	36	1	**36.0**
BU71	23	2	11.5

Table 6.27 Minimum number of flakes (MNF) to core ratio in cryptocrystalline in sites from the Piedmont.

Cryptocrystalline	MNF	Cores	Ratio
Unit 105	47	23	2.0
Unit 201	62	1	**62.0**
BU65	41	19	2.2

Table 6.28 Minimum number of flakes (MNF) to core ratio in basalt in sites from the Piedmont.

Basalt	MNF	Cores	Ratio
39- Rute 40 North	383	5	**76.6**
Rute 40 South	137	1	**137.0**
Unit 115	371	1	**371.0**
Unit 264	45	1	**45.0**
Unit 372	41	2	20.5
Unit 388	43	7	6.1

6.4.3 Non-cortical flake to cortical flake

An increase in core reduction should lead to a lower proportion of cortical surfaces on flakes. The MNF::core ratio revealed that cryptocrystalline materials were more intensively used in the Highlands and basalt materials were more intensively used in the Piedmont. Then, the ratio non-cortical::cortical flakes should be higher for cryptocrystalline in the Highlands and higher for basalt in the Piedmont. The results indicate the opposite for the Highlands, which has higher ratio values for basalt (Table 6.30). The results for the Piedmont demonstrate that basalts were also more intensively used in comparison to cryptocrystalline (Tables 6.31, 6.32); however, the basalt ratio show much less intensive use in comparison to the Highlands (Tables 6.30, 6.32).

Table 6.29 Non-cortical::cortical flakes ratio for cryptocrystalline in the sites from the Highlands.

Cryptocrystalline	Non- Cortical	Cortical	Ratio
Perdido 1	495	313	**1.6**
Unit 80 - Perdido 4	33	28	**1.2**
Unit 10	1	2	0.5
Unit 163	5	2	**2.5**
Perdido 5	181	109	**1.7**
BU16	2	2	1.0
BU62	3	4	0.8

Table 6.30 Non-cortical::cortical flakes ratio for basalt in the sites from the Highlands.

Basalt	Non- Cortical	Cortical	Ratio
Perdido 1	757	36	**37.0**
Unit 80 - Perdido 4	100	15	**6.7**
Unit 10	27	2	**13.5**
Unit 163	20	2	**10.0**
Unit 186	23	2	**11.5**
Perdido 5	147	19	**7.7**
BU16	41	9	4.6
BU50	19	1	**19.0**
BU59	21	22	1.0
BU62	14	4	3.5
BU71	9	16	0.6

Table 6.31 Non-cortical::cortical flakes ratio for cryptocrystalline in the sites from the Piedmont.

Cryptocrystalline	Non- Cortical	Cortical	Ratio
Unit 39 - Rute 40 North	16	26	0.6
Unit 105	12	58	0.2
Unit 115	70	71	1.0
Unit 201	13	52	0.3
BU65	6	54	0.1
Rute 40 South	46	35	1.3

Table 6.32 Non-cortical::cortical flakes ratio for basalt in the sites from the Highlands.

Basalt	Non- Cortical	Cortical	Ratio
Unit 39 - Rute 40 North	340	67	**5.1**
Unit 115	336	66	**5.1**
Unit 264	18	28	0.6
Unit 265	18	15	1.2
Unit 320	37	13	**2.8**
Unit 372	20	27	0.7
Unit 380	31	16	1.9
Unit 388	32	19	1.7
Unit 389	17	8	2.1
BU65	2	1	2.0
Rute 40 South	99	44	**2.3**

6.4.4 **Unmodified flake to tool ratio**

The unmodified flake to tool ratio is a simple measure of tool production. Low values for this ratio mean that in proportion more flakes are modified into tools. Therefore, higher values for this ratio suggest less intense use. In both ecological zones there is considerable variability among sites suggesting that different activities were taking place (Tables 6.33-38). In the Highlands there is a more intense use of cryptocrystalline compared to basalt (Tables 6.33, 6.34); and highlights the lower values for obsidian for a few sites (Table 6.35). In the Piedmont, units 389 and 372 indicate lower values for basalt (Table 6.36); unit 39-rute 40 and unit 115 north indicate lower values for cryptocrystalline (Table 6.37). The site unit 115 in the Piedmont has a lower ratio for obsidian (8.5), compared to the values in the sites Perdido 5 (15.7) and Perdido 1 (59.1) from the Highlands (Tables 6.35, 6.38).

Table 6.33 Unmodified flake::tool ratio for basalt in sites from the Highlands.

Basalt	Unmodified flake	Tool	Ratio
Unit 10	29	2	14.5
Unit 163	21	1	21.0
Unit 186	24	1	24.0
BU16	50	3	16.7
BU59	41	1	41.0
BU62	17	1	17.0
Unit 80-Perdido 4	115	1	115.0
Perdido 1	793	5	158.6

Table 6.34 Unmodified flake::tool ratio for cryptocrystalline in sites from the Highlands.

Cryptocrystalline	Unmodified flake	Tool	Ratio
Unit 80-Perdido 4	61	2	30.5
Perdido 5	290	8	36.3
Perdido 1	808	9	89.8

Table 6.35 Unmodified flake::tool ratio for obsidian in sites from the Highlands.

Obsidian	Unmodified flake	Tool	Ratio
Unit 10	2	1	2.0
Unit 163	1	2	0.5
Perdido 5	157	10	15.7
Perdido 1	178	3	59.3

Table 6.36 Unmodified flake::tool ratio for basalt in sites from the Piedmont.

Basalt	Unmodified flake	Tool	Ratio
Unit 39 - Rute 40 North	407	3	135.7
Rute 40 South	143	2	71.5
Unit 115	402	7	57.4
Unit 265	33	1	33.0
Unit 372	47	3	15.7
Unit 380	47	1	47.0
Unit 388	51	1	51.0
Unit 389	25	2	12.5

Table 6.37 Unmodified flake::tool ratio for cryptocrystalline in sites from the Piedmont.

Cryptocrystalline	Unmodified flake	Tool	Ratio
Unit 39 - Rute 40 North	42	4	10.5
Rute 40 South	81	1	81.0
Unit 115	47	2	23.5
Unit 201	62	1	62.0

Table 6.38 Unmodified flake::tool ratio for obsidian in sites from the Piedmont.

Obsidian	Unmodified flake	Tool	Ratio
Unit 115	17	2	8.5

6.5 **Site groups**

To stablish similarities and differences among the archaeological sites in the Diamante valley, both from the Highlands and the Piedmont, I generated a Gower's coefficient of similarity matrix (Gower 1985) (Table 6.40) from the multivariate dataset presented in Table 6.39. The analysis chosen follows the criterion proposed for mixed variable datasets by Drennan (2009:280). The program used to generate the matrix was SIMS designed by Robert Drennan.

The dataset includes 24 cases and 12 variables. The dataset contains these variables: 1) 0%, 50% and 100% cortex for each site; 2) the proportions of basalts, cryptocrystalline, and obsidian; 3) the proportions of tools, cores and debitage; the presence and absence of ceramics in each site; average volume of lithic artifacts measured in mm^3 (multiplying height, width and thickness of each piece); and finally, the density-area index for each site calculated as described previously. Then, I generated a cluster tree analysis in SYSTAT 12 from the matrix obtained (Table 6.40, Figure 6.16).

Table 6.39 A multivariate dataset on archaeological sites from the Diamante valley.

Site	0% cortex	50% cortex	100% cortex	Basalt %	Cryptocrystalline %	Obsidian %	Tools %	Cores %	Debitage %	Ceramics	Lithic volume	Area-density index
39-Rute 40 North	79.2	12.9	7.8	89.0	9.1	1.3	2.4	1.3	96.3	0	10467	0.265
Unit 115	75.5	17.6	6.9	71.3	25.0	3.5	2.3	0.2	97.5	0	5653	0.056
Unit 380	63.3	26.5	10.2	95.9	4.1	0.0	2.0	0.0	98.0	0	15539	0.005
Unit 265	54.5	36.4	9.1	100.0	0.0	0.0	3.0	0.0	97.0	0	14441	0.003
Unit 320	73.6	9.4	17.0	94.3	1.9	1.9	0.0	0.0	100.0	0	8201	0.005
Unit 389	68.0	12.0	20.0	100.0	0.0	0.0	8.0	0.0	92.0	0	16846	0.003
Unit 10	88.6	8.6	2.9	82.9	8.6	8.6	8.6	0.0	91.4	0	3377	0.004
Unit 163	87.5	9.4	3.1	68.8	21.9	9.4	9.4	3.1	87.5	0	6340	0.003
Unit 186	92.0	4.0	4.0	100.0	0.0	0.0	4.0	0.0	96.0	0	4140	0.003
BU 16	80.4	16.1	3.6	89.3	7.1	3.6	5.4	0.0	94.6	0	7485	0.006
BU 50	92.0	4.0	4.0	80.0	12.0	8.0	0.0	0.0	100.0	0	5683	0.003
BU 59	48.8	39.5	11.6	100.0	0.0	0.0	2.3	2.3	95.3	0	17065	0.004
BU 62	71.4	28.6	0.0	64.3	25.0	10.7	3.6	0.0	96.4	0	1752	0.003
Unit 372	42.0	42.0	16.0	94.0	4.0	2.0	6.0	4.0	90.0	0	21883	0.005
Unit 264	39.1	41.3	19.6	100.0	0.0	0.0	0.0	2.2	97.8	0	48916	0.005
Unit 388	62.7	17.6	19.6	100.0	0.0	0.0	2.0	13.7	84.3	0	36162	0.005
BU 71	36.0	20.0	44.0	100.0	0.0	0.0	0.0	8.0	92.0	0	100984	0.003
Unit 201	20.3	56.3	23.4	0.0	100.0	0.0	1.6	1.6	96.9	0	5096	0.007
BU 65	14.1	37.5	48.4	4.7	93.8	1.6	0.0	29.7	70.3	0	47974	0.006
Unit 105	18.3	53.5	28.2	1.4	98.6	0.0	1.4	32.4	66.2	0	45920	0.007
Rute 40 South	65.6	19.9	14.1	59.3	33.6	4.6	2.5	0.4	97.1	1	9714	0.073
80-Perdido 4	77.9	17.1	5.0	57.8	30.7	10.6	1.5	0.5	98.0	1	4907	0.154
Perdido 5	78.1	16.3	5.6	26.5	46.3	26.7	2.9	0.5	96.6	1	2733	0.357
Perdido 1	80.2	17.5	2.3	43.9	44.8	10.6	2.2	0.9	97.0	0	2289	1.041

Table 6.40 Gower's coefficient of similarity for the 24 archaeological sites from the Diamante valley, based on the data from Table 6.39.

		39-Rute 40 North	Unit 105	Unit 115	Unit 201	Unit 264	Unit 265	Unit 320	Unit 372	Unit 380	Unit 388	Unit 389	BU 65	Rute 40 South	Unit 10	80-Perdido 4	Unit 163	Unit 186	Perdido 5	BU 16	BU 50	BU 59	BU 62	BU 71	Perdido 1
1	39-Rute 40 North	1																							
2	Unit 105	0.4698	1																						
3	Unit 115	0.9246	0.5087	1																					
4	Unit 201	0.6524	0.7918	0.7023	1																				
5	Unit 264	0.7903	0.6085	0.7791	0.7279	1																			
6	Unit 265	0.8783	0.5366	0.8685	0.7155	0.8943	1																		
7	Unit 320	0.9038	0.4764	0.8908	0.6623	0.8503	0.8713	1																	
8	Unit 372	0.8043	0.5802	0.7897	0.7002	0.8753	0.8907	0.8106	1																
9	Unit 380	0.907	0.5276	0.9014	0.7047	0.8756	0.9537	0.9121	0.8638	1															
10	Unit 388	0.8263	0.6098	0.8091	0.6278	0.8457	0.8494	0.8434	0.8318	0.8758	1														
11	Unit 389	0.8548	0.4721	0.8266	0.6227	0.8037	0.8692	0.8744	0.8656	0.8789	0.8609	1													
12	BU 65	0.4688	0.8922	0.5095	0.7182	0.6156	0.5276	0.5022	0.5668	0.5186	0.6007	0.463	1												
13	Rute 40 South	0.8034	0.4675	0.8614	0.6544	0.7016	0.7783	0.7853	0.7178	0.8095	0.7263	0.7411	0.4683	1											
14	Unit 10	0.8491	0.3947	0.848	0.5621	0.6819	0.7875	0.8208	0.7883	0.8053	0.7421	0.8767	0.3956	0.7218	1										
15	80-Perdido 4	0.8029	0.4107	0.8543	0.6035	0.6505	0.7228	0.7633	0.6456	0.7635	0.6703	0.6824	0.4115	0.9224	0.7487	1									
16	Unit 163	0.8118	0.4307	0.8446	0.5691	0.6484	0.7428	0.776	0.7663	0.7605	0.7324	0.832	0.4317	0.7247	0.9446	0.7547	1								
17	Unit 186	0.9002	0.421	0.8752	0.6112	0.7738	0.8795	0.8882	0.7929	0.8835	0.8113	0.878	0.412	0.7421	0.886	0.744	0.8328	1							
18	Perdido 5	0.7228	0.372	0.7472	0.5651	0.5278	0.6288	0.6421	0.5535	0.6486	0.5623	0.5929	0.3728	0.8257	0.6601	0.8742	0.6635	0.6542	1						
19	BU 16	0.9199	0.4497	0.9158	0.6289	0.7658	0.8711	0.8833	0.8457	0.8892	0.8101	0.8883	0.4507	0.7863	0.916	0.7839	0.8712	0.9226	0.6928	1					
20	BU 50	0.876	0.4248	0.8922	0.6148	0.7579	0.8065	0.9077	0.7263	0.8469	0.7511	0.7824	0.4506	0.7605	0.8806	0.8045	0.8404	0.9017	0.6816	0.8791	1				
21	BU 59	0.8653	0.5705	0.8482	0.7335	0.9193	0.9661	0.8585	0.9122	0.9379	0.8612	0.8563	0.5551	0.7641	0.7621	0.704	0.7291	0.8505	0.6013	0.8457	0.785	1			
22	BU 62	0.8475	0.4931	0.9156	0.6852	0.7467	0.8524	0.8197	0.7858	0.8634	0.7471	0.789	0.4941	0.8171	0.8509	0.8337	0.8513	0.8414	0.7438	0.8809	0.8554	0.8214	1		
23	BU 71	0.7132	0.5508	0.696	0.5997	0.8476	0.7618	0.7658	0.7607	0.7704	0.8196	0.7495	0.6245	0.6205	0.6262	0.5661	0.5975	0.6985	0.4492	0.697	0.6738	0.7857	0.642	1	
24	Perdido 1	0.8121	0.4348	0.8396	0.6294	0.624	0.7106	0.7325	0.6354	0.7428	0.6565	0.6689	0.4356	0.7479	0.7499	0.8025	0.7547	0.7401	0.7773	0.7802	0.782	0.6938	0.8351	0.5435	1

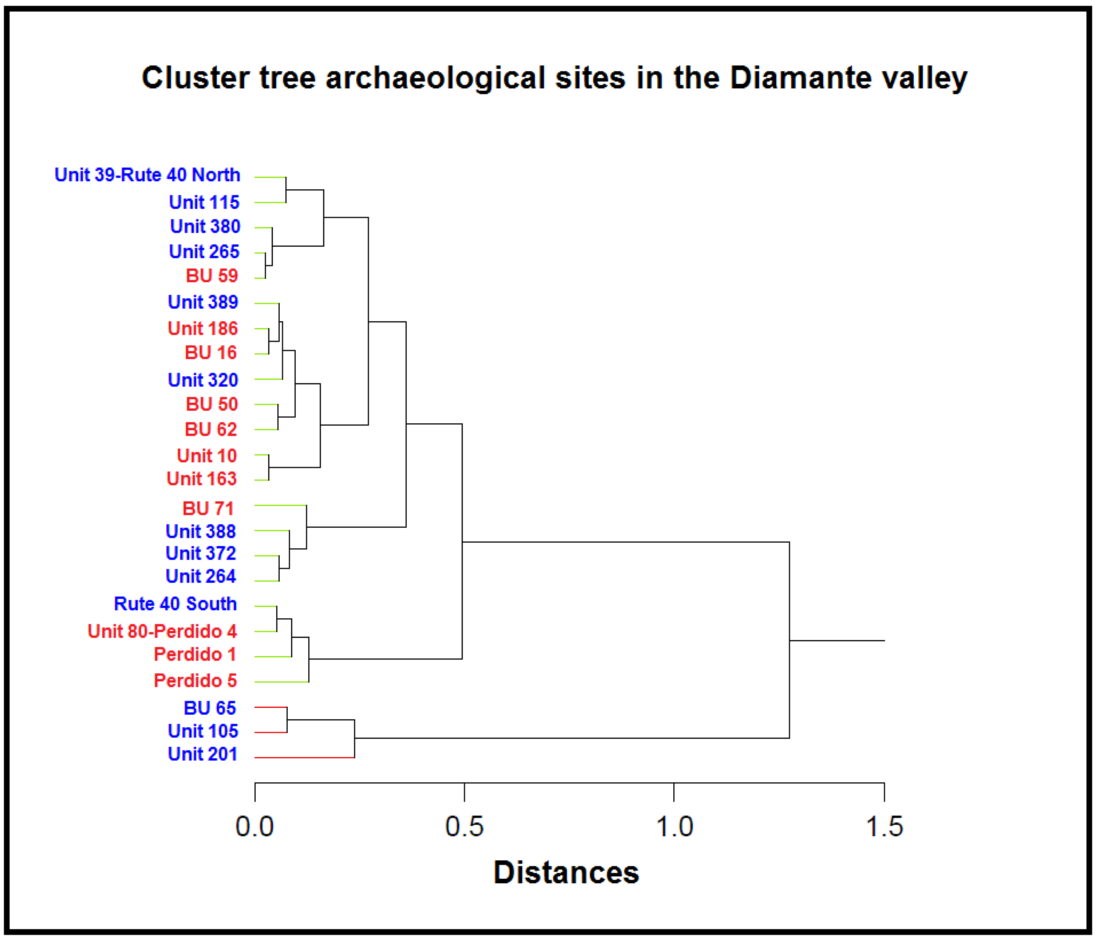

Figure 6.16 Cluster tree for archaeological sites in the Diamante valley. Piedmont sites (blue), Highlands sites (red).

The cluster tree groups sites very straightforward, I can distinguish 5 groups:

Group 1: Unit 39 - Rute 40 North, Units 115, 380 and 265 from the Piedmont and BU 59 from the Highlands. The first two are the largest sites from the Piedmont which groups with the later three locations, there is a predominance of basalt as the raw material used. They have a certain variability of percentage of cortex, but most artifacts have 0% cortex. This group has two major base camps from the Piedmont which showed persistent occupations and three smaller base camps, two from the Piedmont and one from the Highlands.

Group 2: Units 389 and 320 from the Piedmont; units 10, 186 and 163, and BU 16, 50, and 62 from the Highlands. These middle-size sites present more variability in the raw materials used and the percentage of cortex (which indicates middle stages of lithic reduction). In some of them, there is more abundance of tools, while in others there is more abundance of cores. There are no ceramics in this group of sites. Therefore, I consider that Group 2 refers to special tasks and short-term camps.

Group 3: Units 388, 372, and 264 from the Piedmont and BU 71 from the Highlands, are sites with basalt cores, with high percentages of cortex, and presence of tools. I consider that this group refers to basalt secondary sources.

Group 4: Rute 40 South, Perdido 5, Unit 80- Perdido 4 group with Perdido 1, the first three sites have presence of ceramics and all of them have the larger density-area index values. In addition, they have more presence of obsidian and tools. I consider that this group refers to base camps which indicate more persistent occupations.

Group 5: Units 201 and 105, and BU 65 from the Piedmont are sites with almost exclusively acquisition and use of cryptocrystalline, with high percentages of cortex, and high values for average volume. I consider that this group refers to cryptocrystalline secondary sources.

From this analysis I can interpret that there are two groups that represent base camps: Group 1 for the Piedmont, and Group 4 for the Highlands. Group 3 includes short-term camps and specific task camps, and seems to be more relevant in the Highlands. And finally, Groups 2 and 5 represent secondary sources of either basalt or cryptocrystalline mainly from the Piedmont. Futher detailed analysis of the sites may shed light on multicomponent sites, single event sites, and the internal variability in the assemblages. To improve our understanding of the variability within sites, we would need site formation studies, test units, radiocarbon dating, and obsidian hydration among other data sources.

6.6 **Ceramics analysis at the level of the survey area**

In the Highlands there are five assemblages with ceramics: BU28 (N=1), BU53 (N=1), Perdido 2 (N=9), Perdido 5 (N=119), and Perdido 6 (N=7). In the Piedmont there is only one assemblage with ceramics, Rute 40 South (N=15). There is a marked difference in the frequency of sherds between the Highlands (N=137) and the Piedmont (N=15). To explore the relevance of ceramics in relation to other archaeological materials within samples of sites in the Highlands of the Atuel valley, Neme (2007) elaborated an index that divides the amounts of ceramics by the sum of the rest of archaeological materials in each assemblage. Here, I present the ratio of ceramics divided the amount of lithics to explore a similar trend regarding the relevance of ceramics in the assemblages collected in the survey The ratio of Nceramics::Nlithics is low (>0.19), except for Perdido 6 (0.58) and BU28 (1) (Table 6.41). I will not describe the assemblages BU28 and BU53 for the remaining variables as they only present one sherd each; however, the information is available in the tables (6.42-6.46).

Table 6.41 Ratio of ceramics to lithics per site.

Site	N Ceramics	N Lithics	Ratio
Perdido 6	7	12	0.58
Perdido 5	117	626	0.19
Unit 80 – Perdido 4	9	199	0.04
Rute 40 South	15	241	0.06
BU53	1	6	0.17
BU28	1	1	1.00

Unfortunately, the sample sizes do not allow significant statistical comparisons. However, the findings are homogeneous across the sites. There are two main styles present in both ecological zones, both local styles: Overo (75%), and Marrón Pulido (22.4%) (Table 6.42). The remaining 2.6% correspond to non-local styles.

Table 6.42 Frequencies and percentages of ceramic style per site.

Style	BU28		BU53		Unit 80 - Perdido 4		Perdido 5		Perdido 6		Rute 40 South		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Marrón Pulido	1	100.0	1	100.0	6	66.7%	23	19.3%		0.0%	3	20.0%	34	22.4%
Overo		0.0%		0.0%	3	33.3%	93	78.2%	7	100.0%	11	73.3%	114	75.0%
Others		0.0%		0.0%		0.0%	3	2.5%		0.0%	1	6.7%	1	0.7%
Total	1	100.0%	1	100.0%	9	100.0%	119	100.0%	7	100.0%	15	100.0%	152	100.0%

To measure the degree in investment in ceramic technology I established some expectations in chapter 4. I assume that thinner thickness involves more effort during the manufacture of the piece as it is more instable during the modelling an requires more expertise. Also, reduced firing usually requires implementing special techniques to remove the oxygen from the firing atmosphere, and therefore implies more effort. In addition, a finer temper size implies a selection of the temper before being added to the clay, with requires extra care. And finally, a polished surface treatment involves more time and effort in the manufacture then smoothed and brushed surfaces treatments.

The thickness averages in the assemblages range from 6.2-6.5 mm (Table 6.43). Regarding temper size, 26.3% of the total sample are large; 59.2% medium; and 13.2% fine. Perdido 5 and Ruta 40 Sur present similar percentages of the total sample, while Perdido 6 and Unit 80 have higher proportions of medium temper size (Table 6.44). As for surface treatment, 75% of the total sample are smoothed; 23.7% polished; and 1.3% brushed (Table 6.45). Perdido 5 and Ruta 40 Sur present similar percentages of the total sample, while Perdido 6 has 100% smoothed; and Unit 80 has 66.7% polished and 33.3% smoothed. Only 2% of the sample show reduced firing, indicating low investment for this variable (Table 6.46).

Table 6.43 Average thickness per assemblages.

Site	Thickness	N
Perdido 6	6.5	7
Perdido 5	6.2	117
Unit 80	6.4	9
Ruta 40 Sur	6.5	15
BU53	4.8	1
BU28	7.0	1

Table 6.44 Frequency and percentages of temper size per assemblages.

Temper size	BU28		BU53		Unit 80 -Perdido 4		Perdido 5		Perdido 6		Rute 40 South		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Large	1	100.0%		0.0%	1	11.1%	17	14.3%		0.0%	1	6.7%	20	13.2%
Medium		0.0%	1	100.0%	8	88.9%	64	53.8%	7	100.0%	10	66.7%	90	59.2%
Fine		0.0%		0.0%		0.0%	36	30.3%		0.0%	4	26.7%	40	26.3%
Indet.		0.0%		0.0%		0.0%	2	1.7%		0.0%		0.0%	2	1.3%
Total	1	100.0%	1	100.0%	9	100.0%	119	100.0%	7	100.0%	15	100.0%	152	100.0%

Table 6.45 Frequency and percentages of surface treatment per assemblages.

Surface treatment	BU28		BU53		Unit 80 -Perdido 4		Perdido 5		Perdido 6		Rute 40 South		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Smoothed		0.0%		0.0%	3	33.3%	93	78.2%	7	100.0%	11	73.3%	114	75.0%
Polished	1	100.0%	1	100.0%	6	66.7%	24	20.2%		0.0%	4	26.7%	36	23.7%
Brushed		0.0%		0.0%		0.0%	2	1.7%		0.0%		0.0%	2	1.3%
Total	1	100.0%	1	100.0%	9	100.0%	119	100.0%	7	100.0%	15	100.0%	152	100.0%

Table 6.46 Frequency and percentages of firing per assemblages.

Firing	BU28		BU53		Unit 80 -Perdido 4		Perdido 5		Perdido 6		Rute 40 South		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Oxidized	1	100.0%		0.0%	3	33.3%	94	79.0%	7	100.0%	3	20.0%	108	71.1%
Oxidized Incomplete		0.0%	1	100.0%	6	66.7%	23	19.3%		0.0%	11	73.3%	41	27.0%
Reduced		0.0%		0.0%		0.0%	2	1.7%		0.0%	1	6.7%	3	2.0%
Total	1	100.0%	1	100.0%	9	100.0%	119	100.0%	7	100.0%	15	100.0%	152	100.0%

6.7 **Analysis of ceramics from the Diamante valley**

There is other evidence of ceramics from the Diamante valley. I grouped the findings of ceramics from the surface survey (N=152) and compared them to three other samples. I grouped the ceramics from the sites El mallín and Alero Montiel, excavated by Gambier in the 1970s, together with a sample of Manatial cave, in the sample called rockshelters (N=170). Another sample are the ceramic materials from an excavation at Risco de los Indios (N=284) (Sugrañes 2016), one of the high elevation villages previously described. The fourth sample are the surface collections materials from El Indígeno (N=668) (Franchetti and Sugrañes 2012).

Neme (2007) reports other sherds collected in El Indígeno from an excavation (N=162) and a test pit (N=20), with an average thickness that ranges from 5-7mm. The author mentions the presence of styles Aconcagua Salmon and Diaguita Chileno, clearly associated to Chile. According to Neme, the local styles Marrón Pulido, Negro Pulido, and Gris Pulido described by Lagiglia (1997) could be associated to the Llolleo tradition from Chile. However, in southern Mendoza we still consider them to be local (Sugrañes and Franchetti 2012).

The ceramic analysis published for Laguna del Diamante presents serious problems and unfortunately cannot be used for comparison either (Durán et al. 2006). The data reported incorporates an ad hoc classification based on decoration and surface treatment, that groups all sherds into 13 categories. Then, a cryptic discussion assigns possible connection to styles described for southern Mendoza (Lagiglia 1999) and central Chile (Falabella and Stehberg 1989; Falabella and Planella 1991). For some whimsical reason the description spends paragraphs mentioning colors from the Munsell chart while not reporting accurately variables related to temper size or firing. The thickness averages reported for the archaeological assemblage LD-S2 separates them in structure 1 (4.83 mm) and structure 3 (5.14mm). The average thickness for sherds from the LD-S4 l assemblage is divided by component 1 (5.05 mm), component 2 (4.73 mm), and component 3 (4.30 mm). The sample size for LD-S2 is 46 sherds from two structures, and a private collection, while for LD-S4, the authors report a sample of 193 sherds. It is a shame that the ceramic data from one of the most important archaeological sites in Mendoza province have been reported so poorly.

6.7.1 **Chronology**

Radiocarbon dates have been used as a population proxy in the archaeology of southern Mendoza (Gil et al. 2014). However, there is little information about the chronology of ceramics and projectile points that could help as temporal markers for surface survey collections. Nevertheless, from reported radiocarbon dates associated to ceramics in sites of the Diamante valley (Morgan et al. 2017; Neme 2007; Giardina et al. 2017), I can establish that ceramics were incorporated around 2,300 years BP. Furthermore, there is a higher frequency of radiocarbon dates associated with ceramics, indicating a more consistent occurrence between 1,500 years BP until 500 years BP. From the ceramics samples reported, the style Overo is present across the Late Holocene, from 2300-500 years BP. It is plausible that beyond the earlier dates, ceramics were more used 1,500 years BP, when the presence of different ceramic styles increases (Morgan et al. 2017; Neme 2007).

Particularly, this chronology works mostly for the style Overo, proposed to be used mainly in the Highlands and the Piedmont (Lagiglia 1997). This trend would permit us to explore two possible hypotheses: 1) Different styles of ceramics belong to different periods of time across the Late Holocene; 2) All the ceramics styles in the region are continuously present during the Late Holocene but their densities and distribution vary between the Highlands and the Lowlands.

6.7.2 **Ceramic trends in the Diamante valley**

The amount of local styles in the four archaeological assemblages ranges from 3 to 5; while the non-local styles remain constant with 1 (Figure 6.17, Table 6.47). However, it is highly probable that many descriptions of the local styles made by Lagiglia (1999) could also be considered as Chilean styles described by Fallabella and Planella (1991).

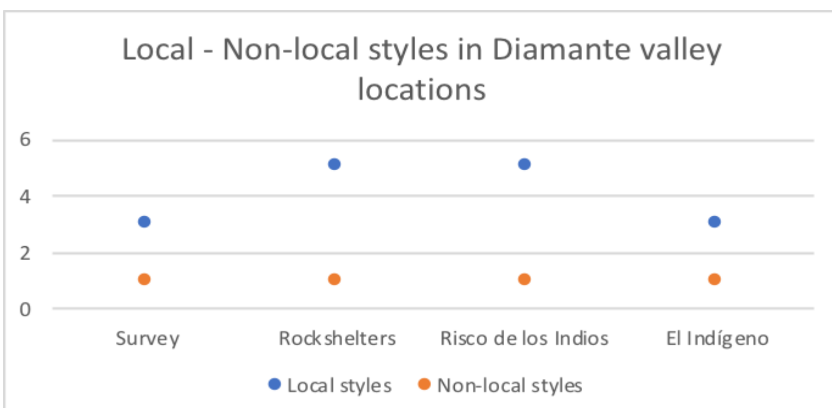

Figure 6.17 N local and non-local style in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages.

Table 6.47 N local and non-local style in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages.

Styles	Archaeological assemblages			
	Survey	Rockshelters	Risco de los Indios	El Indígeno
Local	3	5	5	3
Non-local	1	1	1	1

There are no published data available to establish an error range for the ceramic sherds of Risco de los Indios, however the average reported is 6.91 mm (Sugrañes 2016). Figure 6.18 demonstrates a box-and-dot plot for the thickness averages, we can observe that the median increases slightly from el Indígeno, the rockshelters, and the survey assemblages respectively. The survey assemblage has 6.3 ± 0.33 mm average thickness; the rockshelter assemblage has 5.8 ± 0.17 average thickness, and El Indígeno has 5.4 ± 0.13 average thickness, at a 95% confidence level. Figure 6.19 indicates that these assemblages are not significantly different (less than 95% confidence level) in the thickness averages, evidencing an increasing investment for this variable from El Indígeno, then the rockshelters, and finally the survey assemblage.

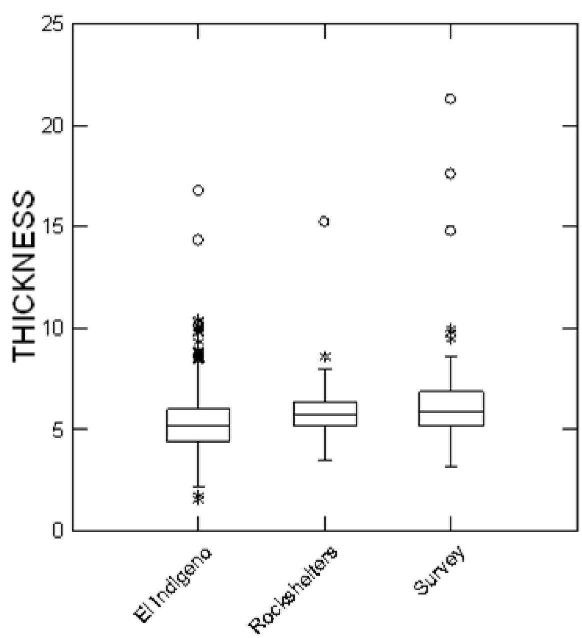

Figure 6.18 Box-and-dot plot comparing average thickness (in mm) at El Indígeno, the rockshelters, and the survey assemblages.

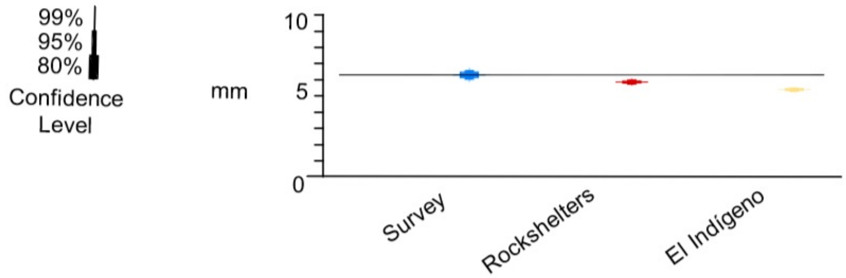

Figure 6.19 Bullet graph comparing thickness averages (in mm) at El Indígeno, rockshelters, and survey assemblages.

In Tables 6.48-50 there are the frequencies and percentages for temper size, surface treatment, and firing in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages. The description of each proportion value with the corresponding error range is reported below together with bullet graphs.

Table 6.48 Frequencies and percentages of temper size in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages.

Temper size	Survey		Rockshelters		Risco de los Indios		El Indígeno	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Fine	40	26.3%	30	17.6%	56	25.5%	89	13.3%
Medium	90	59.2%	107	62.9%	121	47.4%	453	67.8%
Large	20	13.2%	25	14.7%	69	27.1%	58	8.7%
Indet.	2	1.3%	8	4.7%	0	0.0%	68	10.2%
Total	152	100.0%	170	100.0%	255	100.0%	668	100.0%

Table 6.49 Frequencies and percentages of surface treatment in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages.

Trat Sup	Survey		Rockshelters		Risco de los Indios		El Indígeno	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Smoothed	114	75.0%	143	84.1%	199	70.1%	572	86.5%
Polished	36	23.7%	14	8.2%	81	28.5%	50	7.5%
Brushed	2	1.3%	7	4.1%	3	1.1%	0	0.0%

Indet	0	0.0%	6	3.5%	1	0.4%	46	6.9%
Total	152	100.0%	170	100.0%	284	100.0%	668	100.0%

Table 6.50 Frequencies and percentages of firing in the survey, rockshelters, Risco de los Indios and El Indígeno assemblages.

Firing	Survey		Rockshelters		Risco de los Indios		El Indígeno	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Oxidized	108	71.1%	42	24.7%	200	70.4%	505	75.60%
Oxidized Incomplete	41	27.0%	53	31.2%	36	12.7%	126	18.86%
Reduced	3	2.0%	69	40.6%	48	16.9%	22	3.29%
Indet	0	0.0%	6	3.5%	0	0.0%	15	2.25%
Total	152	100.0%	170	100.0%	284	100.0%	668	100.0%

The survey assemblage has 26.3% ± 6.9% of fine temper size; the rockshelters assemblage has 17.6% ± 5.5% of fine temper size, Risco de los Indios has 25.5% ± 4.2% of fine temper size, and El Indígeno has 13% ± 2.4% of fine temper size, at a 95% confidence level. The survey assemblage has 59.2% ± 7.6% of medium temper size; the rockshelters assemblage has 62.9% ± 3.5% of medium temper size, Risco de los Indios has 47.4% ± 3.4% of medium temper size and El Indígeno has 67.8% ± 1.3% of medium temper size, at a 95% confidence level. The survey assemblage has 13.2 ± 5.3% of large temper size; the rockshelters assemblage has 14.7% ± 5.6% of large temper size, Risco de los Indios has 27.1% ± 4% of large temper size and El Indígeno has 8.7% ± 2.5% of large temper size, at a 95% confidence level. In Figure 6.20 by observing the black line that crosses the bullet graphs from the proportion value, we can interpret that the differences in fine temper size proportions are significant for rockshelters and El Indígeno at a 80% confidence level.

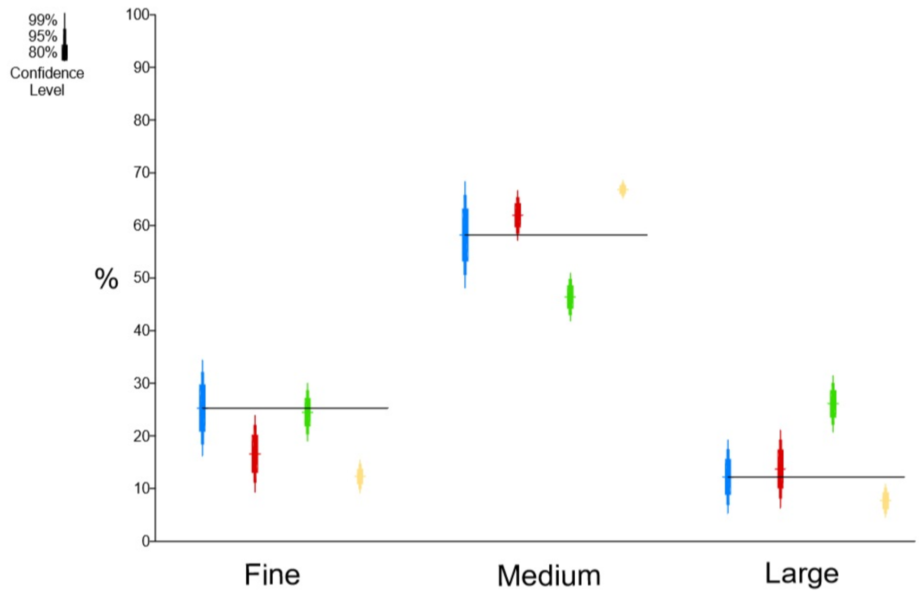

Figure 6.20 Bullet graph comparing temper size percentages in the survey (blue), rockshelters (red), Risco de los Indios (green) and El Indígeno (yellow) assemblages.

The survey assemblage has 75% ± 6.8% of smoothed surface treatment, the rockshelters assemblage has 84.1% ± 4.84% of smoothed surface treatment, Risco de los Indios has 70.1% ± 5.2% of smoothed surface treatment, and El Indígeno has 86.5% ± 1.9% of smoothed surface treatment, at a 95% confidence level. The survey assemblage has 23.7% ± 6.7% of polished surface treatment, the rockshelter assemblage has 8.2% ± 12.9% of polished surface treatment, Risco de los Indios has 28.5% ± 8.2% of polished surface treatment, and El Indígeno has 7.5% ± 6.5% of polished surface treatment, at a 95% confidence level. In Figure 6.21 by observing the black line that crosses the bullet graphs from the proportion value, we can interpret that the differences in smoothed surface treatment proportions are significant for all the assemblages at a 80% confidence level.

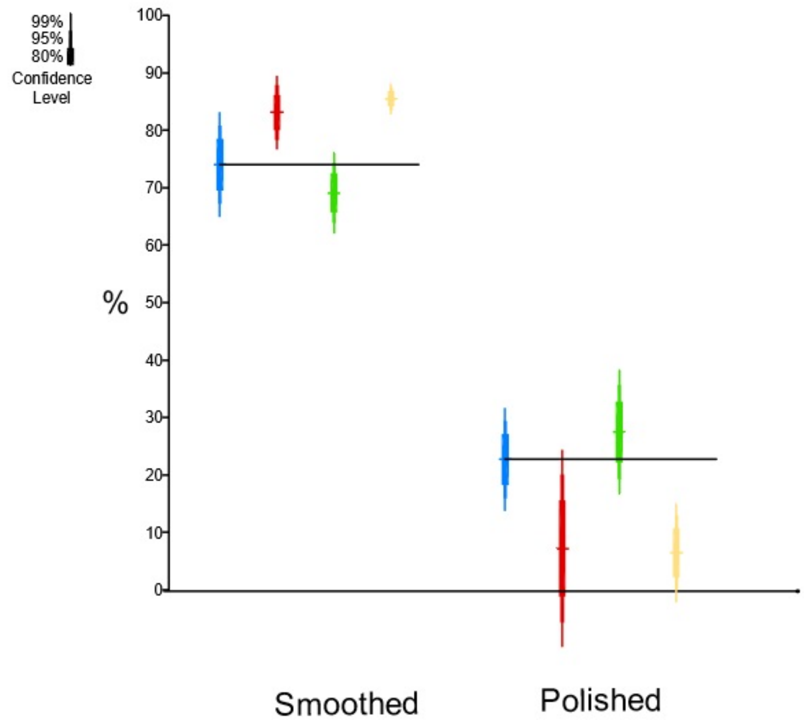

Figure 6.21 Bullet graph comparing surface treatment percentages in the survey (blue), rockshelters (red), Risco de los Indios (green) and El Indígeno (yellow) assemblages.

The survey assemblage has 71.1% ± 7.2% of oxidized firing; the rockshelter assemblage has 24.7% ± 6.3% of oxidized firing, Risco de los Indios has 70.4% ± 5.3% of oxidized firing and El Indígeno has 75% ± 3.1% of oxidized firing, at a 95% confidence level. The survey assemblage has 27% ± 7% of oxidized incomplete firing; the rockshelter assemblage has 31.2% ± 6% of oxidized incomplete firing, Risco de los Indios has 12.7% ± 9.1% of oxidized incomplete firing and El Indígeno has 18.8% ± 5.8% of oxidized incomplete firing, at a 95% confidence level. The survey assemblage has 2 ± 2.2% of reduced firing; the rockshelter assemblage has 40% ± 5.5% of reduced firing, Risco de los Indios has 16.9% ± 8.8% of reduced firing and El Indígeno has 3.29% ± 6.4% of reduced firing, at a 95% confidence level. In Figure 6.22 by observing the black line that crosses the bullet graphs from the proportion value, we can interpret that the differences in reduced firing proportions are significant for rockshelters and Risco de los Indios at a 99% confidence level.

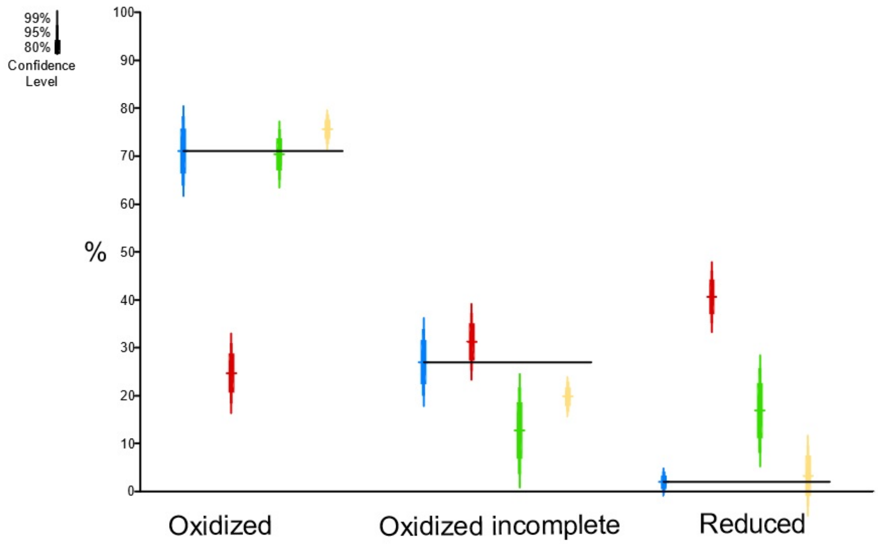

Figure 6.22 Bullet graph comparing firing percentages in the survey (blue), rockshelters (red), Risco de los Indios (green) and El Indígeno (yellow) assemblages.

From these ceramic results, and beyond some variability among the assemblages, I observe a general pattern which consist of: average thickness suggests a low level of investment between 5 and 7 mm; temper size percentages are mostly medium between 40-70%; firing technique is mostly oxidized, except for a 40% of reduced firing in the rockshelter assemblage; and the surface treatment is mostly smoothed with ranges of 60-90%. Overall these assemblages for the Diamante valley ceramics indicates a trend towards low investment.

These results connect to the research questions presented in chapter 1. The second research questions asked: Does site structure reflect uses specific to the different ecological zones? the results demonstrate that site-structure in the Highlands and the Piedmont differs. In the Highlands there are more middle-size camps, perhaps related to hunting while in the

Piedmont middle-size sites are most likely associated with quarrying. The lithic organization also differs among sites: cores are more important in the Piedmont whereas tools are more important in the Highlands. Obsidian and cryptocrystallines are more abundant in the Highlands than they are in the Piedmont, perhaps because basalt is less abundant in the former than in the latter. The percentage of cortex is also more abundant in sites from the Piedmont supporting the idea of more quarrying activities in this ecological zone. The fourth research question asked: How was ceramic technology used in the three ecological zones? Ceramics are more abundant in the Highlands and their use is also present and more important in high-elevation villages and some rockshelters. The investment in ceramic technology, beyond some internal variability, is low. This is consistent with the logic proposed by Sturm et al. (2016) that when hunter-gatherers stay in summer camps they will tend to invest less in this technology because they do not expect to use if for very long, and there is a conflict with other activities important to subsistence during this season.

7.0 Discussion

The research presented in this dissertation examines the use of land in the Diamante valley across three ecological zones: the Highlands, the Piedmont, and the Lowlands. Chapters 2 and 3 outlined the environmental and cultural background for the Diamante valley and the deserts of northern Patagonia. Chapter 4 explained the surface survey methodology used to collect data in similar fashion across the ecological zones. Chapter 5 reported the data at the scale of the ecological zones regarding archaeological material densities, organization of stone tool technology, and ceramic technology. Chapter 6 explored the structure of sites within each ecological zone, incorporating materials recovered outside the systematically surveyed units, and making emphasis on sites with more than 25 archaeological materials. In the following discussion, I link these results to each of the four research questions postured in Chapter 1. I use the idea of "persistent places" to explore the likely patterns of prehistoric human mobility among and within the ecological zones. I also discuss the reasons that might explain the extremely limited findings in the Lowlands. In addition, I discuss the timing and use of ceramics as closely related to subsistence strategies rather than ritual activities. I integrate these results with the information from adjacent valleys from southern Mendoza.

7.1 **Were the Lowlands, the Piedmont and the Highlands occupied with the same intensity?**

In order to explore change in the adaptive strategies of small-scale societies, we must also understand the archaeological landscape, the distribution of archaeological materials, and the taphonomic processes that impact site formation. This dissertation identified how mobility and subsistence were organized, from the perspective of the archaeological landscape, by assessing differences in land use across different ecological zones of the Diamante valley.

The evidence from the systematic random sampling indicates that the Piedmont has a higher proportion of units occupied, followed by the Highlands, and then the Lowlands. In addition, the area-density index demonstrates higher densities of occupation in the Piedmont. This suggests that the Piedmont was an attractive place for people to live throughout the year. Furthermore, archaeological sites cluster in the eastern portion of the Piedmont, while there are larger sites along Perdido stream in the Highlands.

This work demonstrates that we can better understand human adaptations by measuring the intensity of land use, revealing how the three ecological zones were used differently and complementarily. I observe that the use of raw materials differs in the Highlands and the Piedmont. Basalts, which are more abundant in the Piedmont, pulled human occupation towards the east. This is evident by the densities of materials, as well as the percentage of cortex on stone tools, both of which indicate a distance-diminished rate from the largest source to the intersection of the Carrizalito stream in the valley.

There are no obsidian cores or flakes with cortex, indicating that in both ecological zones this raw material was entering already processed and in the last stages of reduction. In addition, its presence is mostly confined to the larger sites. However, the frequency and proportions of obsidian are much higher in the Highlands, considering the proximity to the source Laguna del Diamante, this suggests that as we move further from the source, there is less of this raw material.

Although both the proportion of units with human occupation and the density of occupations that reveal that land use was more intense in the Piedmont than it was in the Highlands, different variables from the organization of lithic technology shows a different picture. Analysis of debitage platforms from both ecological zones points to a more intensive core preparation strategy in the Highlands. This observation is corroborated by the smaller sizes of debitage in the Highlands in comparison to the Piedmont. In addition, cores in the Piedmont tend to be simpler and mainly unidirectional as opposed as higher presence of bidirectional and multidirectional cores in the Highlands. Again, this pattern that indicates a more intense use of raw materials in the Highlands, which is further reinforced by larger core sizes in the Piedmont. However, I didn't find exhausted cores in basalt or cryptocrystalline in any of the ecological zones. Finally, in proportion, there are more projectile points in the Highlands, and they are of smaller size. In the Piedmont, there are more scrapers, a possible proxy for longer stays (Salgán 2013). I interpret these observations as signals of different strategies for risk-management. In the Highlands, the more unpredictable distribution of resources and the difficulty of transport, demonstrates an intense use of raw materials favoring smaller sizes of cores and flakes and the transport of bifaces as more flexible toolkits. In addition, both debitage and cores indicates higher preparation and care at the different stages of tool-making in the Highlands.

The lack of findings in the Lowlands might be a result of problems due to visibility or site formation in a context of floodplains. Another issue to explore, is the possibility that the Spaniards altered the river course after the colonization of Mendoza, meaning that the area selected may have experienced a significant water stress. However, I consider that this area had low human occupation, mainly because this was a bad place to live. However, this area might have been burned intentionally and recurrently in an effort to boosting the prey encounter rates and improve circulation. The Lowlands present higher taxonomic diversity but lower bioproductivity (Otaola et al. 2015).

One plausible solution, to test visibility problems, is to survey units at burned areas, since the burning is a phenomenon that occurs naturally by lightning every two decades or so. This could help to evaluate if visibility is the main factor affecting the low rate of archaeological recovery. Random test pits and core drilling are not recommended for areas with limited human presence (Drennan et al. 2015), but could be done in sites to explore internal formation process and therefore assess sediment deposition rates. Another strategy could be to target sand dunes to determine the deposition rate for the area, along with the deflation processes involved in site formation and destruction. Without further studies, I can only suggest that human activity in the Lowlands was extremely limited.

The density of materials is higher in the Highlands when we consider the information recovered between the systematically surveyed units, but is considerably higher in the Piedmont when I only consider the results from the systematically surveyed units. However, for the comparisons among ecological zones, the results within the one hectare units of the systematic random sampling fulfill the rigor I established to assign confidence to my conclusions. The additional information may be biased towards detecting larger sites in the walks between units. However, this extra information helps me to understand the variability of site structures within the ecological zones. Overall, the unit results revealed consistently the settlement patterns and land use in the Highlands and the Piedmont.

7.2 **Does site structure reflect uses specific to the different ecological zones?**

By site structure I refer to the similarities and differences in the archaeological materials among assemblages that indicates plausible complementary use of space by organizing settlements around different subsistence needs, perhaps at different times throughout the year. The differences among sites could be related to changes in subsistence across time, function, or identity-cultural reasons. I focused on the discussion of different function in the sites which had a sample size larger than 25 archaeological materials. Among these sites, the first observation is that the larger and denser sites were located next to water sources, and specifically at the intersection of different streams with the Diamante river. This is an obvious expectation for hunter-gather adaptations to deserts, but in this case is reinforced by the complementary proximity to raw material sources.

While each ecological zone had local strategies for the use of space and resources, they were complementary, probably with fusion of the bands during winter and fission of the bands during summer (Durán 2000, Gil 2006, Neme 2007). I observe a differential use of raw materials, tied to the local availability of raw materials, which is analogous to what I could expect for the use of different animal and plant resources (Otaola et al. 2019). The role of cryptocrystalline raw materials was more important in the Highlands than in the Piedmont. In addition, by observing the importance of obsidian and ceramics in the sites of the Highlands, I can suggest that indeed this area had a different strategy involving a more intensive pattern of occupation during the Late Holocene at certain locations. The frequency of ceramics is ten times greater in the Highlands than in the Piedmont. This tendency to use a new technology oriented to maximize energetic returns in the Highlands has also been observed in other high-altitude locations as such as the great basin of the US (Morgan et al. 2012b), Tibet (Barton 2016), and the Atuel valley (Neme 2007), among others.

Even more prominent is the florescence of high elevation villages such as El Indígeno, Risco de los Indios, and Laguna del Diamante. These sites are located at an elevation range of 2,600-3,300 masl with stone structures and items from both sides of the Andes suggesting aggregation places unique to the Late Holocene. The proximity of the sites el Perdido 1, 4 and 5 to these high-elevation villages (around 20 km away) suggests the interaction during summer between different human groups occupying areas of the Highlands and people from the western side of the Andes.

The proportion of higher percentage of cortex, less abundance of obsidian, and larger sizes of debitage, cores and tools indicate a considerably lower intensity of use of local raw materials, such as basalts and cryptocrystallines, in the Piedmont in comparison to the Highlands. Measurements from the Highlands indicate lower values than in the Piedmont, demonstrating that the lithic organization was designed to reduce the costs of transport by using reduced-size raw materials.

Cluster analysis suggests that in the Piedmont secondary sources of lithic raw materials were important. This is clearer for the locations where cryptocrystallines were extracted, which are locations somewhat farther from water sources. This multivariate analysis also demonstrates that the base camps in the Highlands were more equipped with ceramics and obsidian, all located next to the Perdido stream, as opposed to in the Piedmont, where only one base camp had ceramics. In addition, short-term base camps were more present in the Highlands, an observation consistent with the proposition for high-altitude adaptations in the high plains of the United States (Bender and Wright 1988). The results from the Highlands conform to their expectations about the importance of middle-size camps dedicated to three different tasks: quarrying, gathering, or hunting. Group 2, described before in chapter 6, follows this pattern.

A closer look at the site Group 2, which represent short-term or special-task sites in the Highlands, indicates the reason why tools were more represented in this ecological zone. Specialized task camps in these locations would have been an important component of a logistical foraging strategy (sensu Binford 1980). This is opposite to the Piedmont, in which there are a few large persistent places and many other satellite locations that are mostly related to raw material acquisition; an observation reinforced by the high proportions of cores and high proportions of cortex.

The persistent places are locations in the landscape that evidence recurrent activity through time. The results of all the ratios explored for lithic assemblages indicate an even consistency for the larger sites. In Surovell's terms (2012), if we take into account the ratios of local::non-local debitage as a proxy of sedentism, then the occupation of sites in the Piedmont, next to water sources would be similar and slightly more stable than the sites located along the Perdido stream in the Highlands.

Neme (2007) applied a central place model (Bettinger et al. 1997) to explain the logic behind the occupation of high-altitude sites in the Highlands of the Atuel valley. The central place model assumes that people choose to live in places close to water sources and resource patches where the collection of plants (e.g. *Prosopis flexuosa*) can be done for several days, thereby reducing the cost of movement between locations (Bird and O'Connell 2006:154). In addition, raw material sizes indicate that local materials were somewhat less abundant and/or that they were being processed to diminish transport costs to the base camps.

In sum, the results indicated that different kinds of sites were common along Perdido stream in the Highlands and that the same locations were not necessarily occupied repetitively. In the Piedmont there is also an indication of persistent places in the major sites, with even higher values for certain ratios, which confirms that there were longer stays in an ecological zone that was available all year round.

7.3 **How did people use mobility to manage the landscape of the Diamante valley?**

Here I suggest that the human foragers of Mendoza used mobility (specifically, spatial averaging across different ecological zones, sensu Goland 1991) to minimize the variance in expected outcomes associated with the volatility of desert resources. Movement is the most basic strategy to balance the acquisition of resources that are heterogeneously distributed in space and time across a landscape. Binford (1980) defined two different categories of mobility, the foragers and collectors, to explain a continuum which implied an emphasis either in the movement of people to resources, or the transport of resources to people. Different approaches have attempted to link variables from lithic organization as proxies to discuss mobility among hunter-gatherer groups. Specifically, the biogeographical model presented for lithic organization in Patagonia (Franco 2004, Salgán 2013) makes use of concepts such as curated, for those tools with a longer expected use-life, versus expedient (sensu Binford 1980), for those tools made in the moment with a shorter expected use-life. However, tool-making involves many decisions and variables related to function, design, the availability of raw materials, and the context of use (Nelson 1991). On this last point, it is well known that the personal equipment of a hunter generally is composed of curated tools carefully prepared for maximum precision while hunting and exploring, and therefore found in a high-mobility context (Binford 1980). Overall, the concepts of curated and expedient technology are obscure rather than enlightening if not properly defined, and this is a very difficult task, as the variables involved tend towards equifinality (Nelson 1991, Surovell 2012).

Instead, I follow a more simplistic, more conservative, and far-from-perfect approach. The basic argument is to second the notion that we can assess the persistency of the occupation of a place, or more sedentary, longer stable stays, by looking at certain ratios from lithic assemblages (Surovell 2012). Shiner (2009) explores the notion of persistent places, which generally have advantageous natural features, for example, locations that provide better conditions regarding different environmental variables such as proximity to water, resource availability, slope, and elevation, among others. Also, persistent places can be attractive due to human factors such as aggregation and the trade of goods.

In the current study, the comparison among sites indicates considerable variability among sites for different ratios: Local-non::local debitage; local debitage::non-local tools; minimum number of flakes (MNF) to core ratio; non-cortical flake to cortical flake; and unmodified flake to tool. In addition, the ratio values within a site are not always consistent with more persistent use. However, the larger sites from the Highlands—Perdido 1, Unit 80-Perdido 4, and Perdido 5—consistently indicate persistent use as shown in the values for local::non-local debitage, local debitage::non-local tools, MNF::core ratio for cryptocrystalline raw material, and non-cortical::cortical flakes for both cryptocrystalline and basalt, (for basalt, the values are even higher). Last, the unmodified flake::tool ratio for obsidian in Perdido 1 also indicates a place of persistent use, but I consider this ratio to be less straightforward for my interpretations, as it showed more variability. Higher values in the local::non-local debitage ratio suggest longer stays in a place. In the Piedmont the values are higher, indicating a longer stay. The larger sites from the Piedmont—Unit 115 and Unit39-Rute 40 North—indicated also higher values for local::non-local debitage, local debitage::non-local tools, unmodified flake::tool ratio for cryptocrystalline, MNF::core ratio for basalts, and non-cortical::cortical flakes.

The use of ratios enabled me to explore the relationships among the use of different raw materials in each site, when the frequencies for each category of artifacts used allowed the comparison, in terms of sample size or presence of an item. The variability of values within and among sites is also dependent on different activities within and among sites; also, values may vary if we consider one-stay as opposed to sites that were generated by multiple occupations and present evidence of a large variety of behaviors. But overall, I can see that in general, larger sites yield values consistent with the expectations of persistent use. Actually, the values were more consistent than the results obtained by Shiner (2009). This was most evident for the Perdido sites from the Highlands and in Unit 115 and Unit 39-Rute 40 North in the Piedmont. The site Unit 115, from the Piedmont, indicated more intense use than any other site.

In the Highlands the sites located close to Perdido stream clearly indicate a more persistent use. The value demonstrates an intense use, which is magnified by the fact that these sites could only be occupied during the three months of summer. The proportions of obsidian and ceramics in these sites also reinforce the idea of reoccupation from one year to the next.

Garvey (2015) elaborated a model of lithic raw material procurement for southern Mendoza that modifies the marginal value theorem to include variables for the distance to raw materials, whether they are local or non-local, and their quality. In addition, she proposes that when the mobility circuits expanded during the Late Holocene, we would expect a higher use of obsidian, acquired from nearby sources of summer access in the Highlands. Regardless of changes across time, we could certainly observe that obsidian is more frequent in the Highlands, which is closer to Laguna del Diamante and Las Cargas, following a typical distance-decay pattern.

Salgán (2013) found that in Payunia 90% of the cryptocrystalline materials were locally available. In addition, she found a low proportion in the use of basalts and obsidian. However, she observes an increase in the use of obsidian across time. She proposes a model for Payunia in which human groups mainly acquired and used local raw materials (cryptocrystallines), while doing other subsistence activities. Following her model, more than 90% of the raw material in the sites should be local and all stages of lithic reduction should be observable. There would be differences in the proportions and uses of the raw material according to locations that show different characteristics: when there is water, the raw materials are not farther than 10km away; when only raw materials are available, test pits indicated ephemeral sites; and when both water and raw materials coexist, there are intense signs of human occupation. I observe a similar pattern from the distribution of surface materials in the use of local raw materials at the Diamante valley, where basalts are the most common raw materials used, followed by cryptocrystalline and then obsidian (a non-local raw material).

Pompei (2019) identified a different pattern for the Atuel valley, in which she assessed different circuits of acquisition and use of raw materials. The proportion of obsidian for this valley is close to 40% in the Piedmont and more than 60% in the Highlands, indicating direct acquisition from those sites and farther indirect transport towards the sites at lower ecological zones. In contrast, cryptocrystalline, basalt and other raw materials are acquired locally, which Pompei defines as “cyclical” acquisition. Therefore, the results at a macro-scale indicated a sharp knowledge and use of local raw materials in each locality. Even if obsidian has a much better quality, we find across the macro region that as we get further from the source, obsidian only appears in larger sites. To add to this macro-scale, it is interesting that sites from the “Travesía seca”, the eastern section of San Luis province studied by Heider (2015), indicates a great number of other raw materials and cryptocrystallines that are locally available. But, note that in this area, “local” is at a distance of close to 10 km away, in places associated with springs and shallow lagoons. Here, what we interpret as local differs from the previous areas, as the distance to local materials within this area of San Luis province is higher. The sites are ephemeral and mainly part of palimpsests in deflated sand dunes—a site structure similar to the one found by Shiner (2009) in Australia. In particular, Heider (2015) defined a specific mobility circuit for this area in which he observed a "lithification of the landscape", mainly based on rhyolite, with a "curated" technology, evidenced by higher frequencies of bifaces and tools with multiple edges, which he interpreted as a risk minimization strategy in an extremely uncertain environment, a strategy common to other observations of Central Western Argentina (Durán 2000; Gil 2006).

7.4 **How was ceramic technology used in the three ecological zones?**

Hunter-gatherers face many challenges when incorporating ceramic technology. Mobility, the main strategy for buffering the heterogeneous distribution of resources both in time and space, implies serious constraints on the accumulation of goods. Ceramic technology competes with previous technologies such as basketry and leather manufacturing, which can be lighter and less fragile in transport (Eerkens 2003; Eerkens 2008).

There is high correlation between ceramic technology and sedentism (Arnold 1985), mainly related to the different steps of the manufacture sequence, which involves raw material acquisition, modelling, drying and firing. In 85% of the reported ethnographic cases, clays come from a 1 km radius (Arnold 1985). While vessel modelling can be a short-time activity, drying is often a step that does not take much effort but requires staying in a place until the process is complete, which can take days or weeks, depending on humidity and temperature of the environment. Also, firing is a step in which the whole process is at stake; it can go well and finish with a good production rate, or it can go wrong and be a great loss. Therefore, potters often keep their firing know-how secret—there are many myths regarding the activity to assure more security for the potter (Rice 2015). Furthermore, in the firing stage, the economy of scale plays a key role, being such an important step in the process: it pays off to produce a considerable number of pieces, for example more than 25 (Eerkens et al. 2002).

Before addressing how ceramics were incorporated, I can establish when. Ceramic technology was incorporated 2,300 years BP. Even with a small sample of dates, I observe a gap of 800 years following its first appearance, after which ceramics were consistently in use from 1,500-500 years BP. The Overo style is associated with most of the dates available and a variety of styles are associated with dates around 1,000 years BP. There is a discussion (Jordan and Zvelebil 2009; Hoopes 1987; Rice 1999; Eerkens 2004) regarding the first ceramics in different regions, which could be related with ritual activities and later there might have been a shift to greater importance in subsistence practices. Though the use of ceramics by aggrandizers in chiefdom-like levels of socio-political organization are widely known (Clark and Blake 1994), hunter-gatherers also used ceramics in ritual contexts, and in Argentina this has been documented for the Pampean region (Politis et al. 2001). For southern Mendoza a pattern like that could be inferred from the sites of the Grande river, but Durán (2000) tends to use his own stylistic categories, making comparisons difficult. From other data available in the high elevations of the Diamante (Neme 2007), Payunia, and Nevado (Gil 2006) and ceramic analysis of the Atuel valley (Sugrañes 2016), the evidence indicates that ceramic technology played an important role in the subsistence system—without implying an important role in ritual activities. In fact, the forms studied from museum collections (sample size=45) of southern Mendoza reflect a wide variety of potential functions: pots (30, 66.6%), jars (9, 20%), bowls (3, 6.6%), vessels (2, 4.4%) and a cup

(1, 2.2%) (Sugrañes 2016). This functional variability reflects a greater importance of pots, linked to cooking and storage—reinforcing the idea that the technology is organized around subsistence rather than service.

Hunther-gatherers of the Diamante valley made decisions on how to incorporate ceramics considering the use-time at certain locations while evaluating the manufacturing time and the utility to be gained. From the data collected in the survey, both with the information within units and between units, the Highlands indicates that ceramics are relatively more prominent than in the Piedmont. Eerkens (2003) suggests that a strategy hunter-gatherer use to engage in ceramic technology is through the re-occupation of settlements. By caching pots in these summer settlements people reduce the cost of transport and increase the expected use-time of the pots. The low investment observed in the variables of thickness, temper size, surface treatment and firing, suggest that human groups did not expect to use the pots for very long. This is consistent with the availability of the Highlands only during summer. Also, this could suggest that there was not a re-occupation of these locations each year. This may imply that different locations were occupied across generations in the Perdido stream; however, re-occupation of these sites may not have been the norm. Probably, this secondary tributary of the Diamante river was a mobility pass towards higher elevations patches and the high-elevation villages.

The importance of ceramics in these high elevation locations matches the expectation proposed for the ratio Nlithics::Nceramics (Neme 2007). However, according to Sugrañes (2016) thickness tends to increase with altitude. Beyond the investment prospect in relation to expected use-time, we have to keep in mind that thickness and temper size also tend to be correlated.

Sugrañes (2016) presented data from neutron activation of 100 sherds that come mainly from the Atuel valley with some sherds from Risco de los Indios. She identified that the Overo and Nihuil types grouped together in opposition to the Atuel Cepillado and Arbolito types. This grouping of styles may be associated with the “parcialidades”, described in the Spaniards’chronicles, belonging to bands from the Lowlands and further East, and to other bands that occupied the Piedmont and part of the Highlands. In the Diamante valley the styles Atuel Cepillado and Arbolito have very low frequencies.

The discussion of trade or local production would require further exploration, but I can set a basic framework. It is very likely that ceramics were produced locally as is evidenced by the predominance of certain styles such as Overo and Nihuil for the Diamante valley. The presence of other styles, even in very small frequencies, such as Marron Pulido, Gris Pulido, Negro Pulido (all potentially from Chile), Atuel Cepillado, and Arbolito, suggests that they were acquired through trade or even visits from groups who spent the other months of the year living on the west side of the mountains. The trade of gifts might have reinforced alliances that allowed the use of complementary regions and access to other territories when the groups from one or the other were under nutritional stress (Thomas 1972). A similar pattern has been proposed for southern Mendoza, with the high-altitude villages serving as aggregation areas for groups from different ecological regions (Neme 2007).

In summary, I have observed that the Piedmont was used more intensively in comparison to the Highlands. However, some sites from the Highlands indicate a higher intensity of raw material use, specifically obsidian. Also, ceramics were more prevalent in the Highlands though investment in their production was low, as might be expected for summer camps in mobile societies, in which is the expected use was low. I could also determine that the site structure in the Highlands was similar to other areas of high altitude, where specific task sites were relevant in a context of inferred logistic mobility.

8.0 Conclusions

Land use and risk management strategies in the extreme deserts and high-elevation environments of northern Patagonia relied mainly on the use of mobility across different ecological zones. As mobility diminished, hunter-gatherer capacity to manage resource acquisition may have involved other strategies such as technological change, trade, and storage. To infer mobility from lithic organization is challenging due to equifinality and because the spectrum across the forager-collector models implies that different strategies are used according to the limitation of each ecological zone that is part of the yearly seasonal round. It is very likely that mobility followed a more logistical pattern as altitude increased, favoring seasonal stays close to water and raw materials. The amount of local raw materials used would imply that the larger sites in the Piedmont were occupied for multiple seasons, year after year. In addition to the importance of obsidian and ceramics, the smaller size of all lithics materials, the smaller proportion of cores, and the smaller proportion of percentages of cortex all indicate a more intense use of raw materials and ceramics in sites across Perdido stream in the Highlands. These characteristics of lithic organization were used to manage uncertainty and risk in a context of higher resource heterogeneity.

By assessing different risk levels for the adaptation to different ecological zones and exploring the different intensity of use in lithic organization, we can interpret how mobility was managed in addition to storage, trade, and technological change. The comparative approach within different ecological zones at a macro scale in southern Mendoza indicates to me the variability in the intensity of use of different raw materials: basalts in the Diamante valley, cryptocrystallines in Payunia, and obsidians in the Atuel valley (Salgán 2013, Pompei 2019, Gil 2006, Neme 2007, Durán 2000, Garvey 2012). The acquisition of local raw materials by hunter-gatherers during the regular course of their annual subsistence rounds (i.e. "embedded" procurement) was the most common behavior as opposed to direct and indirect accession of obsidian, the most valuable raw material in the region. This is a first foundation to address mobility patterns within ecological zones, without using chemical compositional analysis.

In this dissertation I have used a systematic random sampling design, with a strong commitment to enlarging the sample size to measure the intensity in the use of land among ecological zones. Compare, for example, the Diamante River sample size of 1,200 survey units to the sample size of 30-60 survey units used in the Atuel river and Llancanelo (Garvey 2012, Gil and Neme 2006). A biogeographical approach in which we assess how humans adapt to different ecological zones needs both positive and negative findings. The use of a proper sample size, enabled me to have confidence in my understanding of the population, which further enables confidence in the comparisons of distinct populations (e.g. lithics or ceramics). This research methodology was designed to collect an adequate sample of equal proportions among three ecological zones with distinct geomorphological, phytogeographic, and zoogeographic characteristics.

This dissertation highlights the importance of surface survey as a complement to excavation. In the Atuel valley, lithic materials from rock shelters and excavations in larger open sites may lead to misrepresentations in the type of artifacts recovered in the assemblages. The results of the analysis of lithics in the Atuel valley indicate low percentages of cortex and low presence of cores (Neme 2007; Pompei 2019). However, these artifacts are very likely found in the surroundings of larger sites, and possibly missed if survey surface collections are not made. Therefore, chronological efforts should focus on the use of test pits, increasing sampling size both in small and larger sites, using multiple test pits in the larger sites if necessary. But even cheaper and more relevant is the use of obsidian hydration to assess the chronology of surface materials. Analysis of site formation and taphonomic processes should complement these efforts by discriminating between single-event sites and multiple-event sites. This could be accompanied with cross-comparison of projectile points and ceramic sherds from different styles to secure a diagnostic chronology for future surface surveys.

I found that the Piedmont had both a larger proportion of units showing human occupation and higher densities of materials. In addition, I established with strong statistical confidence that the sizes of artifacts are larger in the Piedmont than in the Highlands, and that the presence of cores is greater in the Piedmont, while tools are slightly more represented in the Highlands. Also, I observed that the intensity of raw materials varies according to percentage of cortex, which was more abundant in the Piedmont in proximity to a major basalt local source in the east.

Moreover, I determined that raw materials had different intensity of use among the archaeological sites, which enables me to identify a high variability of site function as well as persistent places. The use of cryptocrystalline in the Highlands increased as a complement to the diminished abundance of basalt. Although the geological charts allow us to consider basalts, cryptocrystallines, and other raw materials to be local, the survey enabled me to detect different locations of secondary sources (locations where basalts appear sporadically, mostly blocks displaced by water) with higher percentages of cortex evidencing earlier stages in reduction sequences. This might be an indicator of single-event sites, an observation that also can help us to understand that in the Highlands, the Perdido stream worked as a stable water source for the establishment of similar sites. The consistency of the ratios in interpreting persistent places enables me to infer that these sites may be the products of a cluster of events, perhaps involving a few generations. The size and distribution of the sites in the Perdido stream, together with the low investment in ceramics, leads me to think that human groups were occupying adjacent locations across the stream but not the same spot over and over again.

The intensity of use of the space, as a contribution to measure intensification, points to the need to explore this process at a larger scale. For example, the intensity of use of cryptocrystalline and basalt, according to the ratios, varies in the Highlands and could lead to different conclusions. I could detect the role of certain secondary sources and how the use of raw materials changed according to their availability. Cryptocrystalline and other raw materials are mainly acquired sporadically, while basalts, beyond being available locally, indicate a preference for places where they are more abundant and of better quality. Is the different use of raw materials telling us something about territoriality?

The Lowlands would require testing areas after fires for visibility, as well as testing site formation at riverbanks and sand dunes that show evidence of deflation processes. The sum of factors such as the inability to transit easily through the vegetation, the lack of permanent streams intersecting the river, the absence of raw materials, and the absence of big game such as guanaco, may all be conditions that affected the occupation of this area. Even if they could have been used by managing intentional and controlled fires to free some areas from vegetation and increase the abundance of prey, I consider this area a no man's land.

The results of the survey in the Lowlands contradict the expectation generated from the biogeographic model proposed by Neme and Gil (2008a), in which the archaeological evidence should point to human occupation starting in the Early Holocene and intensifying during the Late Holocene. The results open new questions for understanding how small-scale societies adapt to marginal environments: How different are the patterns of the use within the Lowlands? How did use of the Lowlands complement use of the Piedmont and the Highlands? Is the majority of the

Lowlands a low quality area for human occupation? Was the Lowlands mainly used in areas adjacent to the Piedmont? Are deserts with extreme aridity (in this case, towards the east of the Diamante valley) biogeographic barriers that make human interaction across areas difficult? How does the low quality and availability of raw materials affect the use of space by hunter-gatherers? If the intensification process implies the occupation of marginal environments, why is it that some areas of the Lowlands were never occupied?

To understand the role of the Lowlands in the use of space across the Diamante valley, I propose to focus on the phytogeographic provinces within it, with the Monte province more prominent towards the west and the Espinal province more prominent towards the east. Therefore, I propose two hypotheses and their archaeological markers:

Hypothesis 1: In the ecological zone "Lowlands west", human occupation used the landscape intensively, generating many archaeological sites. This pattern corresponds to the availability and predictability of plant and animal resources, as well as water resources and raw materials, generating low risk conditions for human occupation.

Archaeological markers: The "Lowlands west" is a transition between the Piedmont and the Lowlands, with higher abundance of local basalts and other raw materials, and more proximity to obsidian trade networks. The lithic organization is mainly linked to the use of the local basalts, other raw materials and obsidian. The use of obsidian includes finished and reotuched tools, absence of cores and absence of cortex, indicating it was acquired from other areas and that it was transported in advanced stages of the reduction sequence. The archaeological sites will tend to be of similar size and diversity of archaeological materials, following a more homogenueos distribution of plant and animal resources across the Diamante river.

Hypothesis 2: In the ecological zone "Lowlands east", the human occupations are of short time duration generating a weak archaeological signal. This pattern is due to the high risk and uncertainty of the resources in this environment, and how those conditions affect human occupation.

Archaeological markers: The "Lowlands east" shares ecotone characteristics with the Espinal phytogeographic province in which the vegetation is thicker and bushy, with poor visibility. Water is limited to the course of the Diamante river as tributary streams are absent. Raw materials for stone tool production are rare or absent. Arcaheological sites will tend to appear in deflated areas around sand dunes, in superficial layers perhaps containing palimpsests of multiple occupations. The tools will evidence high retouch activities and multiple edges, indicating risk minimization strategies. The raw materials would be mainly non-local.

A case study from the Alashan desert of Inner Mongolia also exemplifies how the incorporation of new technologies—ceramics, woodworking tools, and microlithics—arose in a context of land use intensity (Bettinger et al. 1994). The same is applicable to the Great Basin of the United States, occupied by the Paiute Shoshone, in which high-elevation environments were occupied in the Late Holocene (e.g. Thomas 1972, Morgan 2009, Bettinger 1978, 1991b, Simms et al. 1997). Williams et al. (2015) synthesize mobility and settlement patterns in Australia during the Holocene, describing a similar pattern in which an increase in the number of people led to reduced mobility and territories became more defined, while boosting the emergence of new technologies. These insights, together with many others, contribute to understanding how the adaptations to marginal environments like those in high-altitudes and deserts involved different approaches to a broad-spectrum of strategies. By learning in which degree they happened, and by comparing different cases within each we improve our understanding of human adaptation across time. The study of human land use in the Diamante valley supports this effort by inviting us to see the differences and similarities, managing different scales of analysis and lines of evidence, while sharing the same research agenda.

There is more to be learned about the florescence of high elevation villages, the potential emergence of networks and trade nodes unknown to the region before 2,000 years BP (Figure 8.1). Moreover, these villages present more evidence of goods from Chile and therefore the increased importance of networking and possibly trade, as opposed to the use of mobility as the main adaptive strategy. Many questions arise: What disrupted the larger occupations of sites like El Indígeno, and the emergence of smaller aggregations such as Risco de los Indios and Los Peuquenes? How many more of these locations are in the Highlands and how can we detect them? What is the connection between these sites and the sites in El Perdido stream?

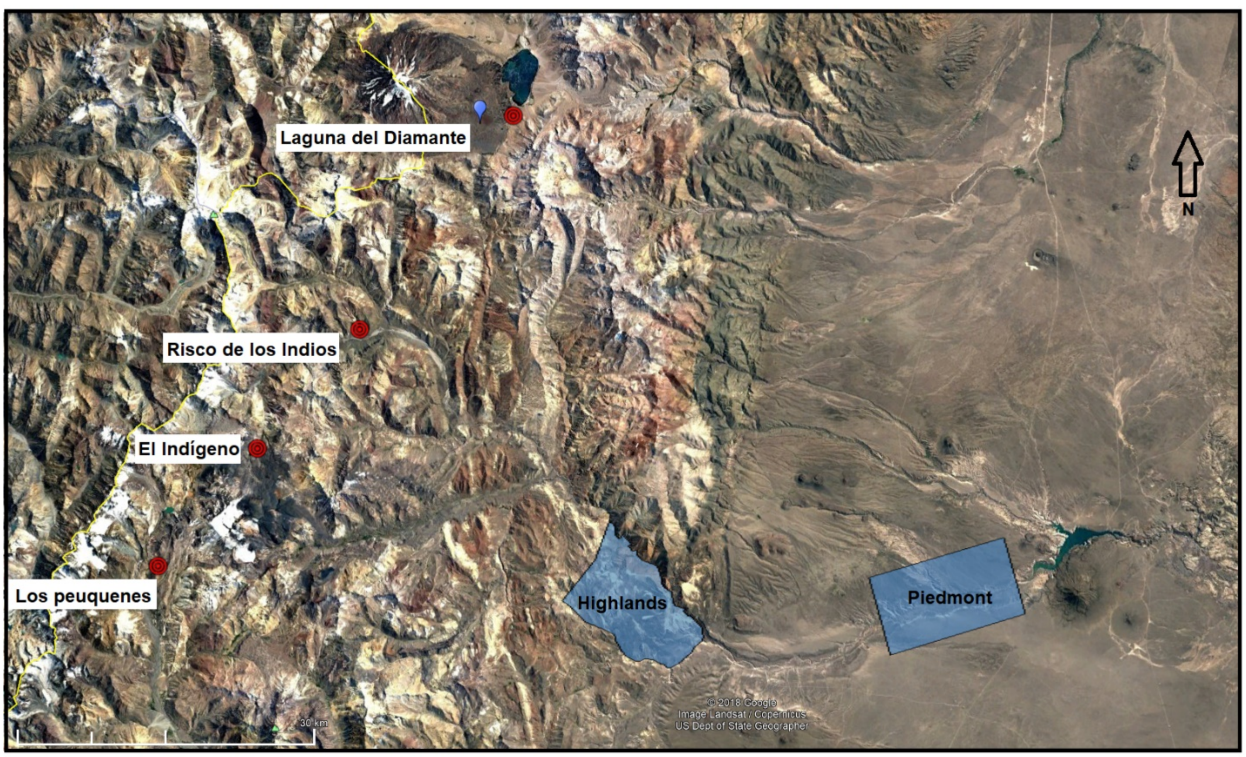

Figure 8.1 Highlands and Piedmont perimeters of the areas prospected in the random systematic sampling. In red, the locations of high elevations villages in southern Mendoza: Los Peuquenes, El Indígeno, Risco de los Indios and Laguna del Diamante. In blue, the obsidian source Laguna del Diamante.

There is a discussion regarding the challenges that high elevation, marginal environments present for human adaptation. Aldenderfer (2006) considers that the risk and uncertainty generated by the scarcity and distribution of resources, which may lead to unbalance of resources and the demographic pressure at lower altitudes, is what makes the occupation of marginal environments more appealing. In contrast, other authors consider that these areas were a complement to mobility circuits allowing the procurement of seasonally abundant resources, such as big game (Bender and Wright 1988; Walsh 2005).

The earliest human occupation of high altitude areas around the world is marked by irregular visits by hunter-gatherers: the Andes (Aldenderfer 1998), the Great Basin of the US (Zeanah, 2000), the Ethiopian plateau (Phillipson 2000) and the Tibetan plateau (Barton 2016). However, is very rare to observe the development of high elevation villages. The topic is of extreme relevance due to the different causes that are being discussed behind the phenomenon: climate change, economic intensification, population increase and migration (Bender and Wright 1988, Bettinger 1991b, Thomas 1982, Morgan et al. 2012a, Barton 2016, Morgan et al. 2012b, Zeanah 2000). In the US there are few locations with evidence of high altitude villages: the White mountains (Bettinger 1991b), Alta Toquima (Thomas 1982), Wyoming's Wind River Range (Morgan et al. 2012b), Utah's Pahvant Range (Morgan et al. 2012a), and the Rocky Mountains (Bender and Wright 1988).

Bettinger (1991b) proposes three scenarios for the emergency of alpine villages: technological change, climate change and regional population growth. He does not see that technological or climate change explain the occupation of alpine villages. Instead, he proposes that demographic pressure in the lowlands was the main cause of human settlement of the highlands, triggered mainly by the expansion of Numic speakers to the area. Bettinger (1991b) argues that the occupation of higher elevations in the White mountains are an adaptive response of hunter-gatherers to population growth in the adjacent lowland areas. Two characteristics are most relevant in this adaptation: longer stays and broadening of the diet breath of high altitude resources (Scharf 2009). In contrast, Thomas (1994) concluded that the Numic expansion was irrelevant for explaining the high elevation occupation of Alta Toquima. Nevertheless, the basic hypothesis about population growth in the lowlands has also been modified to explain early Holocene occupation of the highlands of northeast Tibet (Brantingham et al. 2007; Barton 2016).

The evidence for climatic change is difficult to manage due to the regional scale of the data available, which do not represent accurately the local conditions of the valleys under study. However, both for the Great Basin of the US and for southern Mendoza there are some indications of a warmer dry period occurring during the Medieval Climatic Anomaly that may be associated with changes in resources availability and distribution (Morgan et al. 2012b; Morgan et al. 2017). But the data available are not conclusive in suggesting that climate change is the main reason for human occupation of high elevations. Nevertheless, climate change has also been implicated as the prime mover behind the late Holocene movement of agricultural people into the Tibetan Plateau (Chen et al. 2015).

In addition, Morgan et al. (2012b) explore the chronological trends for high elevation villages in the US concluding that most of the evidence packs between 1,800 and 600 years BP, a chronology that corresponds to the dates from southern Mendoza (Morgan et al. 2017; Neme 2016). These chronological explorations demand that we improve the chronology of surface materials by other dating methods such as obsidian hydration.

What was the role of smaller sites if trade was the most important activity in high-altitude villages? There might be two possibilities: that they help to establish a trade-travel route or that they help to improve the overall efficiency of resource acquisition. Morgan et al. (2012a) tested the trade route argument by doing a least cost path analysis from the Height village to an obsidian source, concluding that middle size camps were not placed on that route. Furthermore, they addressed areas with a slope less than 5 degrees and buffer areas of 8.5km which are related to logistic trips from camps to identify hunting areas within the study area. In addition, they did a least cost analysis among Height village, the middle size camps, and the hunting areas. They recognized that the middle size camps were located within these hunting areas. They concluded that the middle size camps may have enhanced the productivity by almost 10% and may have been used by the people living at Height village. This example shows how different sites at lower altitude may have helped to support the occupation of high elevation villages. It also helps to improve our understanding of the role of trade routes, hunting locations, and raw material acquisition by the use of least cost analysis, buffer analysis, and land use analysis.

Morgan (2009) explores the role of storage through acorn caches around central places from winter camps in the Western Mono, south-central Sierra Nevada. He could stablish that the caches further than 5 km from the winter camps also allowed residential moves during spring. He argues that women's labor, associated with acorn caching, permitted less efficient behavior such as trade and prestige hunting done by men. This division of labor may explain in part the social complexity within small scale groups which may afterwards develop in complex social systems.

The central place model has been used to detect how costs in pursuit, transport, and handling affect foraging returns, allowing people to make decisions regarding where to stablish base camps and villages at high altitude (Aldenderfer 2006, Zeanah 2000, Neme 2007). In addition, the model set the questions of the role of both men and women in providing resources for subsistence (Morgan 2009). The implications of the model suggest that often there was an advantage to establishing base camps in places where it was easier for women to gather resources that would also support the logistical big game hunting trips conducted by men. Specifically, Zeanah (2000) explored the idea that if hunter-gatherers decided to exploit alpine resources by using residential mobility, then it would pay to establish high-altitude central places rather than to continue to use the lowland locations. In contrast, if hunter-gatherers decided to exploit alpine resources by using logistical mobility then it would pay to stablish central places in the lowlands within a catchment area that would allow the hunting trips. In his exploration, he makes emphasis in underscoring values of maximum load, actual processing costs of local resources, and the impact of slope in travelling, among many other variables (Zeanah 2000). The author concludes that a more logistical use, by short-term camps, of the alpine zone was related to low foraging returns and a wider diet breath after the depletion of big game.

It is clear from the literature regarding high elevation villages and settlements, that altitude required the use of multiple strategies to minimize risk: trade, storage, and technological innovation. The trajectories of high elevation villages occupied by hunter gatherers differ among regions and locally among valleys. The variability of these human responses imply that different strategies were at play in their emergence. Among the differences we can detect the following: more logistical or residential mobility, a broadening in the diet versus specialization in the use of certain resources (e.g. acorn, big game), a different emphasis in storage, a different use of the areas at lower altitude, and a different use of technological change, among others.

This context allows me to establish the potential for further comparative studies between the Great Basin of the US and southern Mendoza. The two areas not only share both arid and high elevation conditions, but also show variability within the trajectories of high elevation village life. The role of the main causes already under discussion, climate change, economic intensification, population pressure, and migration may have differed scope or scale in each of the study cases. Therefore, the following questions arise: What can we learn of the occupation of high elevation from looking at lower altitudes? How does the distribution of sites and organization of subsistence change according to altitude, slope, and the distribution of resources? In which scale should we look at demographic pressures? In what degree does this pressure occur by population increase or by to migration? Were the high elevation villages in southern Mendoza occupied by people from the east, the west, or both? Which was the main subsistence system used by the populations that occupied the high elevation villages of southern Mendoza? If these villages were trade nodes between both sides of the Andes, which goods were traded from each side? How can we measure quantitively trade between both sides of the Andes? Was trade mainly focused in gifts that allowed the complementary use of land from both sides of the Andes in bad years?

In this dissertation I assess the importance of mobility for averaging the annual imbalance of resources in the Diamante valley by the use of complementary ecological zones. I could detect with considerable confidence and in a rigorous comparative perspective, the complementary use of space among different ecological zones within the Diamante valley. The Piedmont was the ecological zone indicating a higher intensity of use. I could detect specific strategies used in the Highlands. Finally, I could detect low human occupation in the Lowlands and the need to explore the variability of the use of space within this ecological zone. It is very likely that the use of the Highlands boosted the economic intensification that permitted the establishment of high elevation villages. The change in the strategies used during the late Holocene in the Highlands, namely the use of ceramics and the bow and arrow, together with more logistical mobility, allowed people to adapt better to altitude, enhancing the possibility for them to establish high elevation villages. In this context, trade increased to help to minimize the risk of spatial shortfall, thereby strengthening social networks.

The challenge now, is to improve our chronology, to detect more accurately how the adaptive strategies changed across the Holocene. Was the Piedmont the refugium for arid stress during the Middle Holocene? Were the Highlands used since the early Holocene mostly through hunting activities? What patterns in the use of space can be observed just before ceramics were incorporated? How did the use of obsidian change across the Holocene? Which were the first sources used and how did the use of different sources change as territoriality increased? Were the Lowlands occupied sporadically? Does the Lowlands present differences in its occupation from west to east? What do we gain and how do we contribute to the adaptations of deserts and high altitude by pointing out more detail and internal variability at smaller scales within the ecological zones? Which is the proper scale to explore trade networks? All these questions may contribute to understanding how small-scale societies manage risk, mobility, trade, storage, and technological change in different trajectories across the world in the struggle to adapt to deserts and altitude.

Bibliography

Abraham, E., del Valle, H.F., Roig, F., Torres, L., Ares, J.O., Coronato, F. and Godagnone, R. (2009) 'Overview of the geography of the Monte Desert biome (Argentina)', *Journal of Arid Environments*, 73(2), pp.144-153.

Agüero Blanch, V. (1971) 'Malargüe, pueblo transhumante', *Anales de Arqueología y Etnología,* 24-25, pp.209-223.

Aldenderfer, M. (1998) *Montane foragers: Asana and the south-central Andean archaic*. Iowa City: University of Iowa Press.

Aldenderfer, M. (2006) 'Modelling Plateau Peoples: The Early Human Use of the World's High Plateaux', *World Archaeology*, 38(3), pp. 357-370.

Ammerman, A.J. (1981) 'Surveys and archaeological research', *Annual Review of Anthropology*, 10(1), pp.63-88.

Andrefsky, Jr. W. (1994) 'Raw-material availability and the organization of technology', *American Antiquity*, 59 (1), pp.21-34.

Andrefsky, Jr. W. (1998) *Lithics. Macroscopic approaches to analysis*. Cambridge: Cambridge University Press.

Andrefsky, Jr. W. (2009) 'The analysis of stone tool procurement, production, and maintenance', *Journal of Archaeological Research* 17, pp.65-103.

Andreoni, D.F. (2014) *Plantas leñosas y estrategias humanas en el sur de Mendoza: una aproximación arqueobotánica.* Doctoral dissertation. Facultad de Ciencias Naturales y Museo. Universidad Nacional de la Plata.

Arnold, D. (1985) *Ceramic Theory and Cultural Process. New studies in archaeology*. Cambridge: Cambridge University Press.

Aschero, C. and Hocsman, S. (2004) 'Revisando cuestiones tipológicas en torno a la clasificación de artefactos bifaciales' in Ramos, M., Acosta, A. and Loponte, D. (eds.) *Temas de Arqueología. Análisis Lítico*. Luján: Universidad Nacional de Luján, pp. 7-25.

Baker, S.E. (2005) *The Quaternary history of the Rio Diamante, Mendoza Province, Argentina*. Master dissertation. Dalhousie University.

Bárcena, J.R. (1998) *Arqueología de Mendoza: las dataciones absolutas y sus alcances*. Mendoza: Ediunc.

Barton, L. (2016) 'The cultural context of biological adaptation to high elevation Tibet', *Archaeological Research in Asia,* 5, pp.4-11.

Beall, C.M. (2013) 'Human adaptability studies at high altitude: Research designs and major concepts during fifty years of discovery', *American Journal of Human Biology*, 25(2), pp.141-147.

Belardi, J.B. (2005) *Paisajes arqueológicos: un estudio comparativo de diferentes ambientes patagónicos*. Oxford: British Archaeological Reports.

Bellis, L., Navarro, J., Vignolo, P. and Martella, M. (2006) 'Habitat preferences of lesser rheas in Argentine Patagonia', *Biodiversity and Conservation,* 15, pp.3065–3075.

Bender, S.J. and Wright, G.A. (1988) 'High-Altitude Occupations, Cultural Process, and High Plains Prehistory: Retrospect and Prospect', *American Anthropologist*, *90*(3), pp.619-639.

Bettinger, R.L. (1978) *The surface archaeology of Owens Valley, Eastern California: Prehistoric man - land relationships in the Great Basin*. Doctoral dissertation. Department of Anthropology. University of California, Riverside.

Bettinger, R.L. (1991a) *Hunter-gatherers: archaeological and evolutionary theory*. New York: Plenum Press.

Bettinger, R.L. (1991b) 'Aboriginal Occupation at High Altitude: Alpine Villages in the White Mountains of California', *American Anthropologist*, 93:3, pp.656-679.

Bettinger, R.L., Madsen, D.B. and Elston, R.G. (1994) 'Prehistoric settlement categories and settlement systems in the Alashan Desert of Inner Mongolia, PRC', *Journal of Anthropological Archaeology*, 13(1), pp.74-101.

Bettinger, R.L., Malhi, R. and McCarthy, H. (1997) 'Central place models of acorn and mussel processing', *Journal of Archaeological Science*, 24(10), pp.887-899.

Bibar, G. (1966) *Crónica y Relación copiosa y Verdadera de los Reinos de Chile MDLVIII.* Santiago de Chile: Fondo Histórico y Bibliográfico ''José T. Medina''.

Binford, L.R. (1968) 'Post-Pleistocene adaptations' in Binford, S.R. and Binford, L.R. (eds.) *New Perspectives in Archaeology*. Chicago: Aldine, pp.313–341.

Binford, L.R. (1978) *Nunamiut ethnoarchaeology*. Cambridge, MA: Academic Press.

Binford, L.R. (1980) 'Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation', *American antiquity,* 45(1), pp.4-20.

Binford, L.R. (2001) *Constructing frames of reference: an analytical method for archaeological theory building using ethnographic and environmental data sets*. Berkeley: University of California Press.

Bird, D.W. and O'Connell, J.F. (2006) 'Behavioral ecology and archaeology', *Journal of Archaeological Research*, 14(2), pp.143-188.

Braidwood, R.J. (1960) 'The agricultural revolution', *Scientific American*, 203, pp.30–141.

Boninsegna, J. and Villalba, R. (2006) 'Los condicionantes geográficos y climáticos' in *Documento marco sobre la oferta hídrica en los oasis de riego de Mendoza y San Juan. Primer informe a la Secretaria de Ambiente y Desarrollo Sustentable de la Nación*. Unpublished report.

Borrero, L. (1989) 'Evolución cultural divergente en la patagonia austral', *Anales del Instituto de la Patagonia,* 19, pp.133-140.

Borrero, L. (2002) 'Arqueología y biogeografía humana en el sur de Mendoza' in Gil, A. and Neme, G. (eds.) *Entre montañas y desiertos: arqueología del sur de Mendoza*. Buenos Aires: Sociedad Argentina de Antropología, pp.195-202.

Borrero, L. (2012) 'La Patagonia Cuyana, Logros y Desafíos' in Neme, G. and A. Gil (eds) *Paleoecología Humana en el sur de Mendoza: Perspectivas Arqueológicas*. Buenos Aires: Sociedad Argentina de Antropología, pp. 281-295.

Brantingham, P.J., Gao, X., Olsen, J.W., Ma, H., Rhode, D., Zhang, H., and Madsen, D.B. (2007) 'A short chronology for the peopling of the Tibetan Plateau' in Madsen, D.B., Gao, X., and Chen, F.H. (eds.) *Late Quaternary Climate Change and Human Adaptation in Arid China*. Amsterdam: Elsevier, pp.129-150.

Cabrera, A.L. (1976) 'Regiones fitogeográficas argentinas' in Kugler, W.F. (ed.) *Enciclopedia argentina de agricultura y jardinería.* Buenos Aires: Acme, pp.1-85.

Canals Frau, S. (1946) 'Etnología de los Huarpes. Una síntesis', *Anales del Instituto de Etnografía Americana*, 7, pp.9-147.

Canevari, M., Canevari, P., Carrizo, G., Harris, G., Rodríguez Mata, J. and Straneck, R. (1991) *Nueva guía de las aves argentinas*. Buenos Aires: Fundación Acindar.

Canevari, M. and Vaccaro, O. (2007) *Guía de mamíferos del sur de América del Sur*. Buenos Aires: L.O.L.A.

Capitanelli, R. (1972) 'Geomorgología y Clima de la provincia de Mendoza', *Boletín de la Sociedad Argentina de Botánica, Suplemento del volumen XIII, X Jornadas Argentinas de Botánica. Las ciencias Naturales en la Provincia de Mendoza. Mendoza*, 13, pp.15-48.

Carmanchahi P. D., Schroeder, N., Bolgeri, M., Walker, R., Funes, M., Berg, J., Taraborelli, P., Ovejero, R., Gregorio, P., Moreno, P. and Novaro, A. (2014) 'Effects of live-shearing on population parameters and movement in sedentary and migratory populations of guanacos Lama guanicoe', *Oryx*, 49(1), pp.51–59.

Cashdan, E. (1990) 'Introduction' in E. Cashdan (ed.) *Risk and Uncertainty in Tribal and Peasant Economies*. Boulder: Westview Press, pp.1-16.

Chen, F., Dong, G., Zhang, D., Liu, X., Jia, X., An, C.B., Ma, M., Xie, Y.W., Barton, L., Ren, X.Y., et al. (2015) 'Agriculture facilitated permanent human occupation of the Tibetan Plateau', *Science* 347(6219), pp.248-250.

Cioccale, M.A. (1999) 'Climatic Fluctuations in the Central Region of Argentina in the Last 1000 Years', *Quaternary International,* 62, pp.35–47.

Clark, J. E., and Blake, M. (1994) 'The power of prestige: Competitive generosity and the emergence of rank societies in lowland Mesoamerica' in Brumfiel, E. and Fox, J. (eds.) *Factional competition and political development in the New World*. Cambridge: Cambridge University Press, pp. 17-30.

Cohen, M.N. (1977) *The Food Crisis in Prehistory*. New Haven: Yale University Press.

Corbat, M. (2016) *Variabilidad ambiental y sociocultural en la explotación de peces en el centrooccidente argentino: Una evaluación zooarqueológica*. Doctoral dissertation. Facultad de Filosofía y Letras, Universidad de Buenos Aires.

Corbat, M., Zangrando, A.F., Gil, A.F. and Chiavazza, H., (2017) 'Explotación de peces e intensificación en ambientes áridos: comparando el registro en humedales del centro-occidente de Argentina', *Latin American Antiquity*, 28(2), pp.196-212.

Cornejo, L.E. and Sanhueza, L. (2011) 'North and south: hunter-gatherer communities in the Andes mountains in Central Chile', *Latin American Antiquity*, 22(4), pp.487-504.

Cortegoso, V., Neme, G., Giesso, M., Durán, V. and Gil, A. (2012) 'El uso de la obsidiana en el sur de Mendoza' in Neme, G. and Gil, A. (eds.) *Paleoecología humana en el sur de Mendoza: Perspectivas arqueológicas*. Buenos Aires: Sociedad Argentina de Antropología, pp.181-212.

Crumley, C.L. (1979) 'Three locational models: an epistemological assessment for anthropology and archaeology', *Advances in archaeological method and theory*, 2, pp.141-173.

D'Antoni, H.L. (1983) 'Pollen analysis of Gruta del Indio', *Quaternary of South America and Antarctic Peninsula,* 1, pp.81-109.

De Marco, G., Roig, F.A. and Wuilloud, C. (1993) 'Vegetación del piedemonte andino en el centro oeste de Mendoza (68° 32´-69° 22´ de Long. W y 33°´ 42´-34° 40´ de Lat. S)', *Multequina*, 2, pp.201-241.

Drennan, R.D. (2009) *Statistics for Archaeologists, A common sense approach*. 2nd edition. New York: Springer.

Drennan, R.D., Berry, A. and Peterson, C. (2015) *Regional Settlement demography in archaeology*. New York: Eliot Werner publications.

Dunnell, R.C. and Dancey, W.S. (1983) 'The siteless survey: a regional scale data collection strategy', *Advances in archaeological method and theory,* 6, pp.267-287.

Durán, V. (2000) *Poblaciones indígenas de Malargüe: Su arqueología e historia.* CEIDER, Serie libros Nº 1. Mendoza: Facultad de Filosofía y Letras, Universidad Nacional de Cuyo.

Durán, V., Neme, G., Cortegoso, V. and Gil, A. (2006) 'Arqueología del área natural protegida Laguna del Diamante (Mendoza, Argentina)', *Anales de Arqueología y Etnología.* Special issue 61, pp. 81–134.

Ebert, J. (1992) *Distributional Archaeology*. Salt Lake City: University of Utah Press.

Eerkens, J. (2003) 'Residential mobility and pottery use in the Great Basin', *Current Anthropology,* 44(5), pp.728–738.

Eerkens, J.W. (2004) 'Privatization, small-seed intensification, and the origins of pottery in the western Great Basin', *American Antiquity*, 69(4), pp.653-670.

Eerkens, J. (2008). 'Nomadic Potters. Relationships between Ceramic Technologies and Mobility Strategies' in Barnard, H. and Wendrich, W. (eds.) *The Archaeology of Mobility: Old World and New World Nomadism*. Los Angeles: Cotsen Institute of Archaeology, pp.307-326.

Eerkens, J.W., Neff, H. and Glascock, M.D. (2002) 'Ceramic production among small-scale and mobile hunters and gatherers: A case study from the Southwestern Great Basin', *Journal of Anthropological Archaeology*, 21(2), pp.200-229.

Espizúa, L. (1993) 'Glaciaciones cuaternarias' in V. Ramos (ed.) *Geología y Recursos Naturales de Mendoza.* Mendoza: Relatorio del XII Congreso Geológico Argentino. II Congreso de Exploración de Hidrocarburos, pp.195-204.

Falabella, F. and Stehberg, R. (1989) Los inicios del desarrollo agrícola y alfarero: Zona Central (300 a.C. a 900 d.C.). *Culturas Prehistóricas de Chile (desde sus orígenes hasta los albores de la conquista).* Santiago: Editorial Andrés Bello, pp.295-311.

Falabella, F. and Planella, M. (1991) 'Comparación de ocupaciones precerámicas y agroalfareras en el litoral de Chile Central', *Actas del XI Congreso Nacional de Arqueología Chilena.T.III*, pp.95-112.

Falabella, F. Sanhueza, L., Neme, G. and Lagiglia, H. (2001) 'Análisis comparativo de cerámica Aconcagua entre Chile y Argentina', *Relaciones,* 26, pp.193-214.

Fernández, F.J. (2010) *Microvertebrados del Holoceno de sitios arqueológicos en el sur de Mendoza (República Argentina): aspectos tafonómicos y sus implicancias en la subsistencia humana.* Doctoral dissertation. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata.

Flannery, K.V. (1969) 'Origins and ecological effects of early domestication in Iran and the Near East' in Ucko, P.J. and Dimbleby, G.W. (eds.) *The domestication and exploitation of plants and animals*. London: Duckworth, pp.73–100.

Franchetti, F. and Sugrañes, N. (2012) 'Ceramic technology, environment and residential mobility in small scale groups: preliminary trends from north Patagonia, Argentina', *Before Farming*, 2012(3), pp.1-12.

Franco, N. (2004) 'La organización tecnológica y el uso de las escalas espaciales amplias. El caso del sur y oeste de Lago Argentino' in Acosta, A., Loponte, D. and Ramos, M. (eds*.) Temas de Arqueología. Análisis Lítico.* Luján: Universidad Nacional de Luján, pp.:101-144.

Franklin, W.L. and Fritz, M.A. (1991) 'Sustained Harvesting of the Patagonian Guanaco: Is It Possible or Too late?' in Robinson, J.G. and Redford, K.H. (eds.) *Neotropical Wildlife Use and Conservation.* Chicago: The University of Chicago Press, pp.317-336.

Gambier, M. (1979) *Investigaciones arqueológicas en la región del Alto río Diamante, Provincia de Mendoza*. San Juan: Publicaciones del Instituto de Investigaciones Arqueológicas y Museo.

Gambier, M. (1985) *La Cultura de los Morrillos.* San Juan: Instituto de Investigaciones Arqueológicas y Museo, FFHyA, UNSJ.

Garvey, R. (2008) 'A behavioural ecological approach to a proposed middle Holocene occupational gap', *Before Farming,* 2008(2), pp.1-14.

Garvey, R. (2012) *Human behavioral responses to Middle Holocene climate changes in Northern Argentine Patagonia.* Doctoral dissertation. Department of Anthropology, University of California, Davis.

Garvey, R. (2015) 'A model of lithic raw material procurement' in Goodale, N. and Andrefsky Jr., W. (eds.) *Lithic Technological Systems and Evolutionary Theory*. Cambridge: Cambridge University Press, pp.156–171.

Garvey, R. and Bettinger, R. (2018). 'A regional approach to prehistoric landscape use in west-central Argentina', *Journal of Archaeological Science: Reports*, 19, pp.846-855.

Garvey, R., Carpenter, T., Gil, A., Neme, G. and Bettinger, R. (2016) 'Archaeological age estimation based on obsidian hydration data for two Southern Andean Sources', *Chungara, Revista de Antropología Chilena*, 48(1), pp.1-15.

Giardina M. (2006) 'Anatomía económica de Rheidae', *Intersecciones en Antropología,* 7, pp.263–276.

Giardina, M. (2010) *El aprovechamiento de la avifauna entre las sociedades cazadoras recolectoras del sur de Mendoza, un enfoque arqueozoológico.* Doctoral dissertation. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata.

Giardina, M.A., Neme, G.A. and Gil, A.F. (2014) 'Rheidae egg human exploitation and stable isotopes: trends from West Central Argentina', *International Journal of Osteoarchaeology*, 24(2), pp.166-186.

Giardina, M., Otaola, C. and Franchetti, F. (2017) 'Biogeografía humana en la cuenca del Río Diamante: información arqueológica y perspectivas', *Revista del Museo de Antropología, UNC*, 10, pp.21–32.

Giesso, M., Durán, V., Neme, G., Glascock, M.D., Cortegoso, V., Gil, A. and Sanhueza, L. (2011) 'A study of obsidian source usage in the Central Andes of Argentina and Chile', *Archaeometry*, 53(1), pp.1-21.

Gil, A. (2006) *Arqueología de La Payunia (Mendoza, Argentina).* British Archaeological Reports International Series, 1477. Oxford: Archaeopress.

Gil, A., Giardina, M.A., Neme, G. and Ugan, A. (2014) 'Demografía humana e incorporación de cultígenos en el centro occidente argentino: explorando tendencias en las fechas radiocarbónicas', *Revista Española de Antropología Americana*, 44(2), pp.523-553.

Gil, A., and Neme, G. (2006) 'Distribuciones arqueológicas superficiales en Payunia-Llancanelo', *Anales de Arqueología y Etnología,* 61, pp.163-184.

Gil, A.F., Tykot, R.H., Neme, G. and Shelnut, N.R. (2006) 'Maize on the frontier. Isotopic and macrobotanical data from central-western Argentina' in Staller, J., Tykot, R. and Benz, B. (eds.) *Histories of maize. Multidisciplinay Approaches to the Prehistory, Linguistics, Biogeography, Domestication and Evolution of Maize*. Chicago: Left Coast Press, pp.199-214.

Gil, A., Zárate, M. and Neme, G. (2005) 'Mid-Holocene paleoenvironments and the archeological record of southern Mendoza, Argentina', *Quaternary International*, 132(1), pp.81-94.

Goland, C. (1991) 'Ecological context of hunter- gatherer storage: environmental predictability and environmental risk', *Michigan Discussions in Anthropology. Foragers in Context: Long-term, Regional, and Historical Perspectives in Hunter- gatherer studies,* 10, pp.107-125.

González Díaz, E. (1972) ‘Descripción geológica de la Hoja 27d San Rafael, Provincia de Mendoza’, *Servicio Nacional Minero Geológico*, *Boletín,* 132, pp.1-127.

González Loyarte, M.M., Manenti, M. and Diblasi, A.M. (2009) ‘Mapa bioclimático para las Travesías de Mendoza (Argentina) basado en la fenología foliar’, *Revista de la FCA*, 49(1), pp.105–122.

González, B.A., Palma, R.E., Zapata, B. and Marín, J.C. (2006) ‘Taxonomic and biogeographical status of guanaco Lama guanicoe (Artiodactyla, Camelidae)’ *Mammal Review,* 36(2), pp.157-178.

Gower, J.C. (1985). Measures of Similarity, Dissimilarity, and Distance. In S. Kotz and N.L. Johnson, eds., *Encyclopedia of Statistical Sciences*, Vol. 5. New York: John Wiley and Sons.

Heider, G. (2015) *Los pueblos originarios en el Norte de Pampa Seca. Una mirada arqueológica a los cazadores recolectores del Sur de las provincias de Córdoba y San Luis, Argentina.* Doctoral dissertation, Universidad Nacional de Córdoba.

Heusser, C.J. (1983) ‘Quaternary pollen record from Laguna de Tagua Tagua, Chile’, *Science*, 219, pp.1429-1432.

Hiscock, P. (2002) ‘Quantifying the Size of Artefact Assemblages’, *Journal of Archaeological Science,* 29(3), pp.251–58.

Hoyo J., Elliot, A. and Sargatal, J. (1992) *Handbook of the Birds of the World. Vol. 1. Ostrich to Ducks.* Barcelona: Ediciones Lynx.

Hoopes, J.W. (1987) *Early ceramics and the origins of village life in lower Central America.* Doctoral dissertation. Harvard University.

Jordan, P. and Zvelebil, M. (2009) *Ceramics before farming: the dispersal of pottery among prehistoric Eurasian hunter-gatherers*. Walnut Creek: Left Coast Press.

Kelly, R. (1983) ‘Hunters-gatherers mobility strategies’, *Journal of Anthropological Research*, 39(3), pp.277-306.

Kelly, R. (1992) ‘Mobility/sedentism: concepts, archaeological measures, and effects’, *Annual review of Anthropology*, 21(1), pp.43-66.

Kelly, R. (1995) *The Foraging Spectrum.* Washington & London: Smithsonian Institution Press.

Labraga, J.C., and Villalba, R. (2009) ‘Climate in the Monte Desert: Past trends, present conditions, and future projections’, *Journal of Arid Environments,* 73, pp.154-163.

Lagiglia, H. (1968) ‘Secuencias culturales del Centro-Oeste argentino: Valles del Atuel y del Diamante’, *Revista Científica de Investigaciones del Museo de Historia Natural de San Rafael,* 1(4), pp.159-176.

Lagiglia, H. (1970) ‘Primer diagrama polínico de la estratigrafía arqueológica argentina’, *Actas y Trabajos del Primer Congreso de Arqueología Argentina*, pp.163-167.

Lagiglia, H. (1974) ‘Síntesis cronológico cultural del Centro Oeste Argentino con especial referencia a los valles del Atuel y Diamante’, *Revista del Museo de Historia Natural de San Rafael,* 2(3), pp.83-101.

Lagiglia, H. (1977a) *Arqueología y ambiente natural de los valles del Atuel y del Diamante*. Doctoral dissertation. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. La Plata.

Lagiglia, H. (1977b) ‘Dinámica cultural en el Centro Oeste y sus relaciones con áreas aledañas argentinas y chilenas’, *Actas del VII Congreso de Arqueología Chilena,* 2, pp.531-560.

Lagiglia, H. (1980) ‘El proceso de agriculturización en el sur de Cuyo: La cultura del Atuel II’, *Actas del V Congreso Nacional de Arqueología Argentina,* pp. 231-254.

Lagiglia, H. (1981) ‘Problemática del precerámico y del proceso de agriculturización en el Centro Oeste Argentino’ *Notas del Museo Municipal de Historia Natural de San Rafael,* 24, pp.73-93.

Lagiglia, H. (1997) *Arqueología de Cazadores- Recolectores Cordilleranos de Altura*. San Rafael, Mendoza: Instituto de Ciencias Naturales de San Rafael, Museo Municipal de Historia Natural.

Lagiglia, H. (1999) ‘Nuevos fechados radiocarbónicos para los agricultores incipientes del Atuel’, *Actas del XII Congreso Nacional de Arqueología Argentina*, pp.239-250.

Llano, C. (2011) *Aprovechamiento de los Recursos vegetales entre las sociedades cazadoras recolectores del Sur de Mendoza.* Doctoral dissertation. Neuquén: Universidad Nacional del Comahue.

Llano, C., Neme, G. and Michelli, T. (2011) ‘Plant use intensification among hunter-gatherers in the Diamante river basin, Argentina’, *Before Farming,* 2011(2), pp.1-15.

Lovis, W.A. (1976) ‘Quarter sections and forests: an example of probability sampling in the northeastern woodlands’, *American Antiquity*, 41(3), pp.364-372.

Lyman, R.L. (2008) *Quantitative Zooarchaeology*. Cambridge University Press, New York.

MacArthur, R.H. and Pianka E.R. (1966) 'On optimal use of a patchy environment', *The American Naturalist* 100(926), pp.603-609.

Mares, M.A., Morello, J.H. and Goldstein, G. (1985) 'The Monte desert and other subtropical semi-arid biomes of Argentina, with comments on their relation to North American arid areas' in Evenari, M., Noy-Meir, I. and Goodall, D. (eds.) *Hot Deserts and Arid Shrublands*. Amsterdam: Elsevier Science, pp.203–237.

Markgraf, V. (1983) 'Late postglacial vegetational and paleoclimatic changes in subantarctic and temperate, and arid environments in Argentina', *Palynology,* 7(1), pp.43-70.

Markgraf, V. (1989) 'Paleoclimates in Central and South America since 18,000 BP based on pollen and lake level records', *Quaternary Science Review*, 8, pp.1-24.

Mercer, J.H. (1983) 'Cenozoic glaciation in the Southern Hemisphere', *Annual Review of Earth and Planetary Sciences*, 11(1), pp.99- 132.

Mercer, J.H. (1984) 'Late Cainozoic glacial variations in South America south of the Equator' in Vogel, J.C. (ed.) *Late Cainozoic Palaeoclimates of the Southern Hemisphere*, Rotterdam: A.A. Balkema, pp.45-58.

Morgan, C. (2009) 'Climate Change, Uncertainty and Prehistoric Hunter-Gatherer Mobility', *Journal of Anthropological Archaeology*, 28, pp.382–396.

Morgan, C. (2015) 'Is it intensification yet? Current archaeological perspectives on the evolution of hunter-gatherer economies', *Journal of Archaeological Research*, 23(2), pp.163-213.

Morgan, C., Fisher, J.L., and Pomerleau, M. (2012a). 'High-Altitude Intensification and Settlement in Utah's Pahvant Range', *Journal of California and Great Basin Anthropology*, *32*(1), pp.27-45.

Morgan, C., Losey, A., and Adams, R. (2012b). 'High-altitude hunter-gatherer residential occupations in Wyoming's Wind River Range', *North American Archaeologist*, *33*(1), pp.35-79.

Morgan, C., Neme, G., Sugrañes, N., Salgan, L., Gil, A.F., Otaola, C., Giardina, M. and Llano, C. (2017) 'Late Prehistoric High-Altitude Hunter-Gatherer Residential Occupations in the Argentine Southern Andes', *Journal of Field Archaeology*, 42(3), pp.214-227.

Nelson, M.C. (1991) 'The study of technological organization'. *Archaeological method and theory*, *3*, pp.57-100.

Neme, G. (2007) *Cazadores-recolectores de altura en los Andes meridionales: el alto valle del río Atuel.* British Archaeological Reports International Series, 1591. Oxford: Archaeopress.

Neme, G. (2009) 'Un enfoque regional en cazadores recolectores del oeste argentino: el potencial de la ecología humana' in Barberena, R., Borrazo, K. and Borrero, L. (eds.) *Perspectivas Actuales en Arqueología Argentina.* Buenos Aires: CONICET – IMHICIHU, pp.303-326.

Neme, G. (2016) 'El Indígeno and high-altitude human occupation in the southern Andes, Mendoza (Argentina)', *Latin American Antiquity*, 27(1), pp.96-114.

Neme, G. and Gil, A. (2002) 'La explotación faunística y la frecuencia de partes esqueletarias en el registro arqueológico del sur de mendocino' in Gil, A. and Neme, G. (eds.) *Entre Montañas y Desiertos. Arqueología del sur de Mendoza.* Buenos Aires: Publicaciones de la Sociedad Argentina de Antropología, pp.141-156.

Neme, G. and Gil, A. (2008a) 'Biogeografía humana en los Andes meridionales: tendencias arqueológicas en el sur de Mendoza', *Chungará (Arica)*, 40(1), pp.5-18.

Neme, G. and Gil, A. (2008b) 'Faunal exploitation and agricultural transitions in the South American agricultural limit', *International Journal of Osteoarchaeology*, 18(3), pp.293-306.

Neme, G. and Gil, A. (2009) 'Human occupation and increasing mid-Holocene aridity: southern Andean perspectives', *Current Anthropology*, 50(1), pp.149-163.

Neme, G. and Gil, A. (2012) 'El registro arqueológico del sur de Mendoza en perspectiva biogeográfica' in Neme, G. and Gil, A. (eds.) *Paleoecología Humana en el Sur de Mendoza: Perspectivas Arqueológicas*. Buenos Aires: Sociedad Argentina de Antropología, pp.255-279.

Neme, G., Gil, A., Otaola, C. and Giardina, M. (2015) 'Resource exploitation and human mobility: trends in the archaeofaunal and isotopic record from central Western Argentina', *International Journal of Osteoarchaeology*, 25(6), pp.866-876.

Orton, C., Tyers, P. and Vince, A. (1993) *La Cerámica en Arqueología.* Barcelona: Editorial Crítica.

Otaola, C. (2013) *Zooarqueología en la Cordillera del Sur de Mendoza: un Enfoque Tafonómico.* Doctoral dissertation. Facultad de Filosofía y Letras, Universidad de Buenos Aires.

Otaola, C., Giardina, M. and Franchetti, F. (2019) 'Human biogeography and faunal exploitation in Diamante River basin, central western Argentina', *International Journal of Osteoarchaeology*, 29(1), pp.134-143.

Otaola, C., Giardina, M., Fry, M., Neme, G., and Wolverton, S. (2016) 'Zooarqueología y Tafonomía en Pastores actuales del Sur de Mendoza', *Intersecciones en antropología*, 17(1), pp.121-127.

Otaola, C., Wolverton, S., Giardina, M. and Neme, G. (2015) 'Geographic scale and zooarchaeological analysis of late Holocene foraging adaptations in western Argentina', *Journal of Archaeological Science,* 55, pp.16-25.

Parry, W.J. and Kelly, R.L. (1987) ‘Expedient Core Technology and Sedentism’ in Johnson, J.K. and Morrow, C.A. (eds.) *The Organization of Core Technology*. Boulder: Westview Press, pp.285-304.

Phillipson, L. (2000) ‘Aksumite Lithic Industries’, African Archaeological Review, 17, pp. 49-63.

Politis, G., Martínez, G. and Bonomo, M. (2001) ‘Alfarería temprana en sitios de cazadores—recolectores de la región pampeana (Argentina)’, *Latin American Antiquity* 12(2), pp.167-181.

Pompei, M.P. (2019) *Organización de la tecnología lítica en la cuenca del Río Atuel (sur de la Provincia de Mendoza) durante el Holoceno Tardío*. Doctoral dissertation. Universidad Nacional de La Plata.

Puig, S., F. Videla, S. Monge, and Roig, V. (1996) ‘Seasonal variations in guanaco diet *(Lama guanicoe* Müller 1776) and food availability in northern Patagonia, Argentina’, *Journal of Arid Environments,* 34, pp.215-224.

Rice, P.M. (1999) ‘On the origins of pottery’, *Journal of Archaeological Method and Theory*, 6(1), pp.1-54.

Rice, P.M. (2015) *Pottery analysis: a sourcebook.* Chicago: University of Chicago Press.

Roig, F.A. (1972) ‘Bosquejo fisionómico de la vegetación de la provincia de Mendoza’, *Boletín de la Sociedad Argentina de Botánica, Suplemento del volumen XIII*, 13, pp.49-80.

Roig, F.A., Roig-Juñent, S. and Corbalán, V. (2009) ‘Biogeography of the Monte desert’, *Journal of Arid Environments*, 73(2), pp.164-172.

Rosenzweig M.L. (1968) ‘Net Primary Productivity of Terrestrial Communities: Prediction from Climatological Data’, *The American Naturalist*, 102(923), pp.67-74.

Rusconi, C. (1962) *Poblaciones Pre y Posthispánica de Mendoza. Tomo 3, Arqueología*. Mendoza: Gobierno de Mendoza.

Salgán, L. (2013) *Organización tecnológica y biogeografía humana en La Payunia, sur de la provincia de Mendoza.* Doctoral dissertation. Universidad Nacional de La Plata.

Salgán, L., Garvey, R., Neme, G., Gil, A., Giesso, M., Glascock, M. and Durán, V. (2015) ‘Las Cargas: characterization and prehistoric use of a southern andean obsidian source’. *Geoarchaeology*, 30(2), pp.139-150.

Salgán, L., Gil, A. and Neme, G. (2012) 'Obsidianas en La Payunia (sur de Mendoza, Argentina): patrones de distribución e implicancias en la ocupación regional', *Magallania (Punta Arenas)*, 40(1), pp.263-277.

Salgán, L. and Pompei, M.P. (2017) 'Fuente de obsidiana El Peceño: primeros resultados de su abordaje tecnológico, geoquímico y espacial', *Revista del Museo de Antropología, Suplemento Especial*, 1, pp.51-58.

Schäbitz, F. (1994) 'Holocene climatic variations in northern Patagonia, Argentina', *Palaeogeography, Palaeoclimatology, Palaeoecology*, 109, pp.287-294.

Scharf, E.A. (2009) 'Foraging and Prehistoric Use of High Elevations in the Western Great Basin: Evidence for Seed Assemblages at Midway (CA-MNO-2169), California', *Journal of California and Great Basin Anthropology*, 29:1, pp.11-27.

Scheinsohn, V. (2003) 'Hunter-gatherer archaeology in South America', *Annual Review of Anthropology*, 32(1), pp.339-361.

Shiner, J. (2009) Persistent places: An approach to the interpretation of assemblage variation in deflated surface stone artefact distributions from western New South Wales, Australia. In Fairbairn, A., O'Connor, S. and Marwick, B. (eds.) *New Directions in Archaeological Science* ANU Press, pp.25-42.

Simms, S., Brigth, J. and Ugan, A. (1997) 'Plain- ware ceramics and Residential Mobility: A case study from the great Basin', *Journal of Archeological Science,* 24, pp.779–792.

Smith, E. (1988) 'Risk and uncertainty in the "original affluent society": evolutionary ecology of resource sharing and land tenure' in Ingold T., Riches, D. and Woodburn, J. (eds.) *Hunters and Gatherers: History, Evolution, and Social Change.* Oxford: Berg, pp.222-252.

Sosa Morales, N. (1979) *Historia de un pueblo la villa vieja.* Mendoza: Museo de Historia Natural, Dirección Municipal de Cultura, Departamento de San Rafael, Provincia de Mendoza, Argentina.

Sruoga, P., Etcheverría, M.P., Folguera, A., Repol, D., Cortes, J.M. and Zanettini, J.C. (2005) 'Hoja Geológica 3569-I Volcán Maipo, Provincia de Mendoza', *Boletín del Instituto de Geología y Recursos Minerales, Servicio Geológico Minero Argentino,* 290.

Sturm, C., Clark, J.K. and Barton, L. (2016) 'The logic of ceramic technology in marginal environments: implications for mobile life', *American Antiquity*, 81(4), pp.645-663.

Steward, J.H. (1938) *Basin-Plateau Aboriginal Sociopolitical Groups, vol. 120*. Washington, D.C.: United States Government Printing Office.

Stingl, H. and Garleff, K. (1985) ‘Glacier variations and climate of the Late Quaternary in the subtropical and Mid-latitude Andes of Argentina’ *Zeitschrift für Gletscherkunde und Glazialgeologie, Innsbrucke*, 21, pp.225-228.

Sugrañes, N. (2016) *La tecnología cerámica y su relación con las estrategias de subsistencia y movilidad de las poblaciones humanas en la cuenca del río Atuel (sur de Mendoza) durante el Holoceno tardío*. Doctoral dissertation. Universidad Nacional del Centro de la Provincia de Buenos Aires.

Sugrañes, N. and Franchetti, F. (2012) ‘Antecedentes, problemas y perspectivas del análisis cerámico del sur de Mendoza. Una Puesta al día’ in Gil, A. and Neme G. (eds.) *Paleoecología humana en el sur de Mendoza: Perspectivas Arqueológicas*. Buenos Aires: Sociedad Argentina de Antropología, pp.229-253.

Superina, M., Carreño, N. and Jahn, G. (2009) ‘Characterization of seasonal reproduction patterns in female pichis, *Zaedyus pichiy* (Xenarthra: Dasypodidae) estimated by fecal sex steroid metabolites and ovarian histology’, *Animal Reproduction Science*, 116, pp.358–369.

Surovell, T.A. (2012) *Toward a behavioral ecology of lithic technology: cases from Paleoindian archaeology*. Tucson: University of Arizona Press.

Thomas, D. (1972) *Prehistoric subsistence-settlement patterns of the Reese River Valley, Central Nevada*. Doctoral dissertation. Department of Anthropology, University of California, Davis.

Thomas, D. (1982) *The 1981 Alta Toquima Village project: a preliminary report*. Desert Research Institute, University of Nevada System, Social Sciences Center.

Thomas, D. (1994) ‘Chronology and the Numic Expansion’, in Madsen, D.B. and Rhode, D. (eds.) *Across the West: Human Population Movement and the Expansion of the Numa*, University of Utah Press, Salt Lake City, pp. 56-61.

Tripaldi, A., Zárate, M. and Brook, G.A. (2010) ‘Sucesiones eólicas y fluviales del Pleistoceno Tardío-Holoceno de la Planicie Sanrafaelina; Paleoambientes y Paleoclima’ in Zárate, M., Gil, A. and Neme, G. (eds.) *Condiciones paleoambientales y ocupaciones humanas durante la transición Pleistoceno–Holoceno y Holoceno de Mendoza.* Buenos Aires: Sociedad Argentina de Antropología, pp.213-227.

Tripaldi, A., Zárate, M.A., Brook, G.A. and Li, G. (2011) ‘Late Quaternary paleoenvironments and paleoclimatic conditions in the distal Andean piedmont, southern Mendoza, Argentina’, *Quaternary Research*, 76(2), pp.253-263.

Veth, P., O'Connor, S. and Wallis, L.A. (2000) ‘Perspectives on ecological approaches in Australian archaeology’, *Australian Archaeology,* 50, pp.54-66.

Villalba, R. (1990) 'Climatic fluctuations in northern Patagonia in the last 1000 years as inferred from tree ring records', *Quaternary Research,* 34, pp.346-360.

Wetzel, R.M. (1985) The identification and distribution of recent Xenarthra (5 Edentata). in G. G. Montgomery (ed.) *The evolution and ecology of armadillos, sloths and vermilinguas.* Washington, DC: Smithsonian Institution, pp. 5–21.

Walsh, K. (2005) 'Risk and Marginality at High Altitudes: New Interpretations from Fieldwork on the Faravel Plateau, Hautes-Alpes', *Antiquity*, 79:304, pp. 289-305.

Williams, A.N., Ulm, S., Turney, C.S., Rohde, D. and White, G. (2015) 'Holocene demographic changes and the emergence of complex societies in prehistoric Australia', *PLoS One*, 10(6), p.e0128661.

Winterhalder, B. and Smith, E.A. (2000) 'Analyzing adaptive strategies: Human behavioral ecology at twenty-five', *Evolutionary Anthropology: Issues, News, and Reviews,* 9(2), pp.51-72.

Winterhalder, B., Lu, F. and Tucker, B.T. (1999) 'Risk- sensitive adaptive tactics: models and evidence from subsistence studies in biology and anthropology', *Journal of Archaeological Research,* 7, pp.301-348.

Wobst, H.M. (1976) 'Locational relationships in Paleolithic society', *Journal of Human Evolution*, 5(1), pp.49-58.

Yellen, J.E. (1977) 'Long term hunter-gatherer adaptation to desert environments: a biogeographical perspective', *World Archaeology,* 8(3), pp.262-274.

Zeanah, D.W. (2000) 'Transport costs, central place foraging, and hunter-gatherer alpine land use strategies', *Intermountain Archaeology*, 122, pp.1-14.